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ABSTRACT

This is the final report of a Unesco meeting held in New Delhi, India in April, 1976. Contents include background information, summaries of the inaugural meeting and the organization of the work at the conference, a summary of the discussions in the commissions, closure, recommendations, and annexes. Topics discussed at this meeting were: (1) predicted manpower needs, women in engineering; (2) curriculum design and development; (3) environmental engineers and technicians; (4) continuing education; (5) education-industry interaction in technological education; (6) institution-building interaction in technological education; and (7) cooperation at the international, regional, and country levels. Some of these topics have been printed as separate publications. (HA)

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Final Report

International Conference on the Education and Training of Engineers and Higher Technicians

New Delhi 20-26 April 1976

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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BACKGROUND

1. The International Conference on the Education and Training of Engineers and Technicians was held in New Delhi from 20 to 26 April 1976, with the generous assistance of the Government of India. It was convened by the Director-General of Unesco pursuant to resolution 2.152 adopted by the General Conference of Unesco at its eighteenth session.

2. The Conference fell within category IV of the meetings convened by Unesco, as an international congress in which participants suggested by Member States and by non-governmental organizations were each invited by the Director-General to attend as specialists serving in an individual capacity.

3. The agencies of the United Nations system, and also a certain number of non-governmental organizations, were invited to send representatives or observers.

4. The Conference was attended by 131 individual participants coming from 45 Member States, 5 observers from Member States, 6 observers from United Nations agencies and 19 observers from non-governmental organizations.

5. The terms of reference of the Conference, as stated in the work plan relating to resolution 2.152, were as follows:

"An international conference on the education and training of engineering personnel will be held in 1976 in a developing country. It is expected that there will be some 300 participants, comprising engineering educators, practising engineers and higher technicians, manpower specialists, economists and government officials concerned with the planning of systems of higher technical education. The Conference will review the progress of the programme on international co-operation in engineering education and examine the overall status of international and regional co-operation in this field. It will analyse the relative importance and complementary nature of the education of different categories of engineering personnel and give guidance on the reorientation or restructuring of the programmes of higher technological education in Member States so as to enable them to train personnel to meet their development needs. Particular attention will be given to analysing the experience of developing countries in creating or expanding their institutions for engineering and higher technical education, and to establishing strategies for achieving and maintaining standards of quality and local relevance. The urgent need for training engineering personnel at the technologist and higher technician level will be emphasized".

6. A meeting of experts was held in New Delhi from 8 to 10 October 1975 to prepare for the Conference. In particular, it advised the Director-General on the provisional agenda of the Conference, the time-table, and the main questions to be emphasized.

7. As well as the agenda, SC/TECHED/1, which is given in Annex I, and the annotated agenda, SC/TECHED/4, prepared by Unesco, the participants were provided with a number of documents to form a basis for discussion of specific agenda items. Additional papers were prepared by non-governmental organizations and individuals, as listed in Annex IV.

INAUGURAL MEETING

8. The Conference opened on 20 April 1976 in Vigyan Bhavan, New Delhi.

9. The participants were first welcomed by Mr. K.N. Channa, Secretary-General of the Indian National Commission for Co-operation with Unesco. The inaugural address was then given by Professor S. Nural Hasan, President of the Indian National Commission and Union Minister for Education, Government of India.

10. In his address Professor Nural Hasan referred to the efforts of developing countries to raise the living standards of their people and to enrich the quality of their life. He stressed the crucial rôle of science and technology in human development to build a new and just world order without the current disparities.

11. He then spoke of the Indian experience in building up an infrastructure of science and technology, involving the creation of a large number of institutions for training and research, and he offered to share these facilities with other countries. In doing so he warned of the need to ensure that scientists and engineers in developing countries are as individuals committed to the task of finding solutions for the problems facing the bulk of the common people in these countries.

12. He maintained that science and technology on the one hand, and social sciences and humanities on the other, must be given opportunities to react with each other, especially in curricula, so that technology graduates will be in a position to play balanced integrated rôles in society. In referring to continuing education, he mentioned the need to avoid technological obsolescence and to provide the individual with opportunities for continuing self-improvement and development. The rôle of the teacher was also crucial in the educational system.

13. Professor Nurul Hasan than referred to the growing realization by all countries that they should strive to attain their own national objectives, and at the same time assist in pooling together the international resources of mankind for the solution of global problems. The exchange of educational experience was one of the most important forms of such co-operation. He concluded his inaugural address by stressing the significance of the pursuit of equality as a basic human value, and the rôle of technology in promoting equality and improving the quality of life of human beings all over the world.

14. On behalf of the Director-General of Unesco, Mr. Amadou-Mahtar M'Bow, the Conference was than addressed by Mr. A. Evstafiev, Director of the Division of Technological Research and Higher Education. In thanking the Government of India for its hospitality in providing facilities for the Conference, he stated that as the Conference was specially concerned with development problems it was very fitting that it be held in a country such as India. He pointed out that the Conference was a sequel to a similar meeting held in Paris in 1968.

15. He then reviewed the changes that have taken place since 1968, mentioning the rapid advances that have been made in science and technology, as well as current efforts to establish a new international economic order. The developing countries had to devise technological education systems that satisfy the needs of their societies and economies. For example, rural engineering was an area that needed greater emphasis in many countries, and more account needed to be taken of the rôle of engineers in adapting and creating technology to meet local needs.

16. He then outlined Unesco programmes, first the assistance activities using United Nations Development Programme and other funds, then the Unesco long-term programmes designed to improve mechanisms for regional and international co-operation in engineering education. In doing so he asked the Conference to examine these programmes and advise the Director-General on the changes in priorities which needed to be made. For instance, it was already clear that more needed to be done to strengthen the environmental awareness of engineers. Also, there was a growing interest in regional collaboration through networks of co-operating institutions and through professional associations.

17. In conclusion, he asked the Conference to give special attention to two major problems, namely how to improve technician training and how to help the developing countries educate the engineers and technicians that they need for their economic and social development.

18. The Chairman of the Indian Local Organizing Committee for the Conference, Dr. A. Ramachandran, concluded the inaugural session by thanking Professor Nural Hasan for the wise counsel contained in his address and Unesco for agreeing to hold the Conference in New Delhi. He mentioned the major rôle that the Indian Institute of Technology, New Delhi, has played in making local arrangements, with many of its staff helping with the various aspects of the preparations for the Conference. Finally, he wished participants every success in their deliberations and expressed the hope that they would take the opportunity of visiting educational institutions and cultural sites while in India.

19. The texts of the opening addresses are attached as Annex II to this report.

ORGANIZATION OF THE WORK AT THE CONFERENCE

20. The Conference time-table was arranged so that on Tuesday, 20 April, the inaugural and the plenary sessions, covering agenda items 1-3, were held. For a three-and-a-half day period, from 21 to 24 April, there were then three concurrent working sessions of the Commissions to consider agenda items 4(a) - 4(g). On the final day, 26 April 1976, the Conference again held plenary sessions, discussing agenda items 5-7.

21. At its first plenary meeting the Conference unanimously elected its officers, as follows:

Chairman:	Dr. A. Ramachandran (India)
Vice-Chairmen:	Dr. E. I. Bobkov (USSR) Professor M. O. Chijioke (Nigeria) Dr. A. F. Kaddou (Iraq) Professor H. E. McCallick (U. S. A.) Professor I. Sheikh (Pakistan)
Rapporteur-General:	Dr. M. Chin (Trinidad and Tobago)
Vice-Rapporteur-General:	Dr. J. Adou (Ivory Coast)

22. The Conference then took up agenda item 3: "Main trends in technological education since 1968, current challenges, and perspectives in industrialized and developing countries", with the representative of the Director-General first reviewing the objectives of the discussion and how they related to Unesco programmes of co-operation and assistance. At the end of this session, and again on the morning of Monday, 26 April 1976, the Conference discussed agenda item 5: "Education and training in technological fields as a prerequisite for development. Discussion of possible strategies to be used in the next decade to ensure that education and training will better contribute to world-wide social and economic development".

23. In the discussion, the Chairman first emphasized the importance of science and technology in achieving economic progress and the improvement of the quality of life in any country. He stressed the need for a systems approach to technological education in order to achieve a set of well-defined objectives. He briefly reviewed the developments in technological education in India and highlighted the importance of proper manpower planning and environmental aspects of engineering education. He also discussed the rôle of professional societies and the need for greater industry-education interaction and for the creation of what he termed entrepreneurial engineers.

24. In developing countries, it was important not only to ensure that adequate numbers of engineers and technicians were produced but also that those who were in employment did not stagnate and become technically obsolescent. Also, it was important to have competent engineers and technicians enter critical fields such as operation and maintenance, even though these fields do not always have the academic respectability of more theoretical areas. The training of teaching staff was a key problem in many countries, especially their professional growth and continuing education. He suggested that residencies in engineering practice should be designed to provide clinical practice for all engineering faculty members. He also saw the need for innovative programmes such as industry-oriented post-graduate programmes leading to a Doctor of Engineering Degree for innovative design and development work, in contrast to the research and theory orientation of the Ph. D. Degree.

25. In reviewing the priority fields in which Unesco had been working, he singled out education-industry co-operation as being particularly important, where much needs to be done in the actual realization of measures about whose necessity there is wide agreement. He also mentioned the multidisciplinary nature of modern engineering practice, which required engineers to be trained to work as members of teams.

26. In order to achieve a closer interaction between industry and the academicians the Chairman listed a number of concrete steps which could be taken within institutions and within industry.

27. In concluding his opening remarks the Chairman made a plea for the development of an educational system designed to produce engineering managers with competence to integrate technology into the complex societal needs of both industrialized countries and the less developed countries. He foresaw the broad needs of a developing country under six groupings and recommended the formation of centres of study and research in order to put developing countries in a position to fulfill their national development needs within the next three to four decades. The full text of this address by the Chairman is given in Annex III.

28. During the ensuing plenary discussions a number of participants gave brief reviews of the status of technological education in their respective countries and attempts were made to identify those trends which were of particular importance in meeting the challenges of the future. It became apparent, however, that around the world, different approaches were being used by countries and the approach adopted must depend to some extent on the country's type of economy, the nature of its industry, the structure and traditions of its educational system and on other social factors. Nevertheless much could be learnt from the experiences of others, from their successes and failures and it was in this sharing of experience that much benefit could arise.

29. Many speakers stressed that the speed with which advances in science and technology occurred implied that all engineers, and also technicians, should have a very good fundamental knowledge of science and basic engineering subjects. This also meant that teaching should continually be reinforced by the involvement of staff in research, with every engineering school attempting to keep abreast of world-wide research progress in some areas.

30. On the other hand, the practising engineer played a central rôle in his society, being the agent of change in the living and working environment. Thus special attention had to be paid to the quality and overall balance of engineering training, the final aim being to produce a specialist able to deal with real engineering problems while taking into account existing social conditions, the environment and the future requirements of national economic development.

31. One speaker began by pointing out that the inclusion of technician training in the scope of the Conference illustrated a recent and world-wide trend to give priority to this type of education. He illustrated this with African examples, where the technician enrolments had trebled in recent years. Other trends that he mentioned included the strengthening of contacts between education and industry, and reconsideration of the salary levels of higher technicians.

32. On agenda item 5 which dealt with the question of education and training in technological fields as a prerequisite for development, there was extensive discussion on the need for engineers to be aware of social needs and the need for greater industry-education interaction. Several participants suggested that what was needed for development was a national development or broad profile engineer or rural engineer and this could be achieved by means of humanization of technological education and overlapping of disciplines. One participant suggested that there was urgent need for engineers and technicians to be trained to provide engineering services of a practical nature to villages and rural areas.

33. There was general agreement that a systems approach should be adopted in respect of technological education and that a set of well-defined objectives should first be identified. Most participants also saw the need for a greater number of what might be termed "middle level engineers", engineers with a practical bias. This type of engineer was particularly needed in areas such as the tooling industry, plant engineering and plant maintenance. This posed the question of the distinction between a technician and an engineer and one participant suggested that the technician should be given equal status to that of an engineer. Another participant felt that there was need for a clearer definition of "technician", "technologist" and "engineer".

34. The Conference was given a brief oral review of the results of the World Congress on Educating Engineers for World Development, organized by the American Society for Engineering Education in June 1975, a summary being given in document SC/TECH/MISC. 12. The Congress considered six areas of major concern, namely: agriculture and food; human settlements; energy and resources; industrialization; management and planning; technology and culture. Its follow-up was envisaged as action programmes in the countries of the Congress participants and a series of meetings.

35. The representatives of the World Federation of Engineering Organizations (WFEO) and the Committee of Science and Technology of the International Conference of Scientific Unions (ICSU/COSTED) spoke on development problems, referring to the papers TECHED/MISC. 8 and TECHED/MISC.9. Representatives of other non-governmental organizations also participated actively in the discussion.

36. The important rôles of national professional societies were mentioned by several speakers, especially in disseminating information, guiding education, providing means of an informal and formal nature for the continuing education of their members, and acting as a link between education and society.

37. On the other hand, several speakers deplored the situation prevailing in many countries where industrial management was not interested or involved in the education of engineers and technicians. It was also stated that in some countries this might be due to the low quality and irrelevance of much of the research carried out in engineering schools. Several participants suggested that applied research committees or management councils should be established to interact between industry and academic institutions. In this way practical training, curricula development, and research would be relevant to the needs of industry and the society at large.

38. A participant from an advanced country maintained that the teachers with whom students were in contact were scientists and engineers, usually and basically interested in highly specialized research work. From them the students gained no feeling of dedication towards finding solutions to the broader problems of economic development and social progress.

39. Another speaker pointed out that in some countries in recent years there had been a swing away from emphasis on engineering sciences, and that more applied topics such as design and management were getting greater emphasis. It was also noted that in developing countries it was extremely useful to have engineers and technicians who were well trained in fields like maintenance engineering, plant engineering and quality control.

40. The special problems of developing countries were frequently mentioned. One speaker stated that although in his country engineering was able to recruit the best students from secondary schools, too many were admitted to engineering studies, there was a severe shortage of experienced teachers, the curricula were modelled too closely on those in Western industrialized countries and collaboration with the few local industries was weak. He stated, however, that these shortcomings were now recognized and there was a will to change the situation.

41. Another speaker stated that developments in science and technology were proceeding so quickly that institutions in developing countries could not hope to catch up with the present gap or even prevent it from widening. Information services were a big problem for these countries, because of lack of current periodicals, poor library facilities, language problems and difficulties in communication. It was suggested that Unesco should give priority to overcoming this situation.

42. A numb r of speakers pointed out that in most developing countries the majority of the people live in rural areas, so that if their well-being is to be improved, engineers and technicians had to be prepared to tackel rural problems, living and working away from the cities. One participant said that in the developing countries an engineer oriented towards national development was necessary, having a broad engineering education and the will and capacity to work in different fields.

43. One participant described the situation in his country, which had a university level engineering school, two schools able to train higher technicians, and a system of technical schools created and supported by local communities. He considered these community technical schools to be very promising in their ability to promote rural development, and said that the university undergraduate studies and post-graduate research should be related to the work being done in the community technical schools.

44. Several participants stressed that national investment in the training and retraining of engineers and technicians brought substantial benefits and was necessary for economic growth, especially in the developing countries. It was also pointed out that the scale of these expenditures was often very small in comparison with arms expenditures, which many countries could ill-afford. The need was stressed for the United Nations system and bilateral assistance programmes to continue and expand their aid to developing countries in engineering and technician education, especially to help the least developed countries in establishing schools for training engineering technicians.

45. The Conference also agreed that co-operative assistance programmes between the developing countries themselves had great potential in strengthening or creating institutions for technological education. If properly planned, the costs could be kept low and substantial benefits accrue to the participating countries.

46. The problem of management of institutions training engineers and technicians was raised by one participant, himself in charge of a polytechnic in Africa. The Conference agreed that this was a very important problem, especially for the many rapidly growing institutions in developing countries. It was suggested that, as a first step, Unesco should organize a series of regional training seminars for those entrusted with the management of these institutions.

47. There were several comments on the need for developing countries to structure their engineering and technician courses so that they corresponded to sectorial manpower needs, if necessary forsaking traditional disciplines such as mechanical, electrical, civil and chemical engineering. Mining engineering, agricultural engineering, and public works engineering were quoted as being current programmes of this sectorial type, with rural engineering and environmental engineering also being mentioned.

48. There was considerable plenary and Commission discussion on the problems of brain drain. One of the major causes was stated as being the requirement for potential university teachers to obtain higher degrees, so that they had to study abroad for prolonged periods, often working on research projects of no importance to their home countries. Strengthening of post-graduate facilities in developing countries - which also had aspects of continued dependence - was agreed

to be one means of correcting this situation. Readaptation in the home country was often a major problem, and it was suggested that Unesco should study this brain drain problem as it applied to engineers and technicians. One participant asserted that the industrialized countries could not repay the developing countries in a hundred years for the loss that they had suffered through the brain drain of gifted students in engineering and scientific fields.

49. Throughout the entire discussion on current world problems in technological education and on its contribution to development there was recognition of the fact that better regional and international communication between those involved in engineering and technician education was a key means of stimulating improvement of the quality and relevance of the education received by students. There was a need and a place for action by all the appropriate international and regional organizations of a governmental and non-governmental nature, in particular Unesco, to work together to facilitate communication, especially of information concerning innovations in training and research.

SUMMARY OF DISCUSSIONS IN THE COMMISSIONS

50. The Conference then split up into Commissions to discuss the seven agenda items 4(a) - 4(g). The scheduling of these meetings was arranged so that at first, on 21 April 1976, there was discussion of manpower, social and environmental aspects, and education-industry interaction, which were seen as prerequisites for the subsequent discussion on items dealing with curricula and continuing education.

51. The far-reaching discussions and at times intensive debate which took place throughout the twenty-one working sessions attempted firstly to review the present system of education and training of engineers and technicians in both developed and less developed countries and then to define the problems related to the seven topics which were to be overcome in order to meet their development needs.

52. Throughout the discussions there was concern for the greater involvement of industry in the education of engineers and technicians and emphasis on the need for upgrading the status and increasing the number of technicians in all countries. Coupled with these two concerns was the need to impress on Member States the importance of continuing education of engineers and technicians and the provision of suitable facilities for such education.

53. Last, but by no means least, there was extensive discussion on the engineering education process itself, its direction and scope, in order to fulfil the national development needs of both developed and developing countries. It was generally agreed that a systems approach should be adopted not only in developing suitable curricula, but also in determining manpower requirements. Throughout the Conference there was the call for engineers and technicians to become more aware of the social and environmental aspects of their engineering solutions. The discussion in the Commissions is summarized as follows:

Agenda item 4(a): The quantitative and qualitative estimation of engineering manpower required for national socio-economic development, and the identification of levels and specializations. Women in engineering

54. The Commission began its work by unanimously electing its officers, with Mr. M. W. V. McKensey (Australia) as Chairman; Mr. M. M. Pelegrin (France) as Vice-Chairman, and Miss M. Bolar (India) as Rapporteur. The background documents for the discussion included the annotated agenda (SC/TECHED/4), and the Secretariat paper, "Quantitative and qualitative estimation of technological manpower needs" (SC/TECHED/MISC. 1).

55. Various methodologies for forecasting engineering manpower requirements were discussed. It was pointed out that in addition to the four methodologies described in the Secretariat paper, namely extrapolation from past trends, international comparisons, correlation between occupational structure and indicators of economic and technological development, and the Delphi method, other methodologies or variations of methodologies for manpower forecasting have been used by a number of countries. Some of the country experiences referred to were those in Nigeria, Saudi Arabia, Uganda, Turkey, Ethiopia, Ghana, Ivory Coast, Canada, Australia, United States of America and India. Among these methodologies were sectorial micro-level manpower forecasting, and combinations of micro-aggregates, and various types of surveys.

56. It was emphasized that a number of considerations particular to each country can influence the reliability of forecasts of manpower requirements. These include the degree to which economic and other planning processes are controlled, the predictability of economic growth,

the choice of technologies, and manpower mobility. To this, one could add the need to keep in mind unpredictable environmental and political factors.

57. An unsuspected problem was often that of obtaining a precise and reliable assessment of the present situation, which should, in principle, be fairly easy. As an example of uncertainty, it was pointed out that the number of engineers in the United States could be said to be 400,000 if one counted registered professional engineers, or 800,000 if one counted those holding engineering degrees, or 1,100,000 according to the opinion of employers, or 1,600,000 according to the opinions expressed by individuals in the last population census. Thus the data base for forecasts might be unclear. Finally, a number of considerations at the organization level such as nature of employment opportunities, skill-mix and work design, nature of organizational structure, and levels of entry into an organization, influenced the situation. Consequently, the more sensitive the forecasting methodology to these factors, the more precise and relevant the resulting forecasts.

58. It was pointed out that in any forecasting, certain assumptions had to be made about the industrial growth, technology, and occupation-education relationships, and the closer these assumptions were to reality, the more reliable the forecast. The point was also made that in forecasting one might wish to look at the construction stage of an industry separately from the production stage.

59. The Group concluded that a systems approach to manpower planning was necessary, involving not only a consideration of the factors which had an influence on the quantitative and qualitative manpower forecast and which possibly could be fitted into a model, but also based on a close and continuing dialogue between the economic planner, the educationalist, the employer and the manpower planner. There had to be an inbuilt system of feedback, control and flexibility for adaptation.

60. It was emphasized that although the major objectives of the manpower planning systems for engineers and technicians might be more or less the same for all countries, and there had always to be appreciation of the changing employment requirements and supply, the sub-objectives or the priorities of the system might vary depending upon the national situation. For instance, if the country at a point of time had a surplus of engineers and a shortage of technicians, then the information and analysis of the manpower planning system would be geared to a detailed appreciation of this situation and a different type of planning approach was required for it rather than for a situation where there was a severe overall labour shortage.

61. In discussing the influence of planning on education and training, whether it be formal or non-formal, institutional, in-company or otherwise, the need for job analysis was emphasized. It was felt that for manpower forecasting to be meaningful, gross numbers of engineers and technicians did not suffice, one needed to know the kind of knowledge and skill actually required for the performance of the duties they had to fulfil. For this purpose, it might be necessary to identify job levels. Besides a classification of jobs in terms of predominant characteristics, as discussed in the Secretariat paper, other approaches in terms of classifying the physical and mental skill levels were described.

62. A number of participants described their experiences and the organizational structure that they had established for manpower planning, with links between government, educational institutions and industries. There was general agreement on the conclusion in the Secretariat paper on new concepts in forecasting. It was emphasized that manpower planning was important not merely to the economic planners for making their investment decisions in the context of labour and manpower availability but also to the educational planners and employers in organizing their formal and non-formal education and training programmes.

63. The Commission discussed ways in which there could be co-operation at a national level to improve the effectiveness of the manpower projections. Experiences in some countries of close collaborative efforts were cited and it was felt that the emphasis should be on a process of mutual feedback and review by all concerned agencies. It was felt that continued activity by national groups dedicated to the study of knowledge and skills required for engineering manpower and its utilization should be fostered. Where no national machinery for study existed, it would be desirable to take appropriate steps to set up such national study groups.

64. The lack of technicians was underlined by a number of participants. This might be due to educational structures and especially to the low salary levels and status of technicians. It was agreed that the salary structure and working conditions available to technicians were generally not in line with the importance of the economic rôle that they had to play. Many speakers stressed that it was important to get a clearer idea of the jobs performed by technicians and to

concentrate more effort on technician education in a systematic long-term manner. The Commission felt that the experiences gained in strengthening technician education in various parts of the world as well as experiences gained in training teachers in technician education needed to be reviewed. Active support had to be given to such efforts and there should be wide dissemination of the experiences gained.

65. When looking at manpower planning at the international level, it was felt that co-operation should be both at regional and at international level. One view expressed was that problems of developing countries might require a separate approach to that used for the developed countries. Another speaker stated that problems of labour surplus countries might be different from those in countries with labour shortages. In this context, it was indicated that in one country where there were labour shortages, the government had planned to depend more on women manpower by stimulating their recruitment into jobs for which they were suited, and by inducing men to transfer from soft office jobs to active work in production.

66. Regardless of diversity in the national factors influencing manpower planning systems, sharing of experiences was agreed as being imperative, and the Commission felt that Unesco was the appropriate organization to undertake such action. It was suggested that Unesco could play a rôle not only in facilitating this sharing of experiences and information, but also in promoting studies in manpower planning on issues of common concern to Member States.

67. The Commission considered in great detail the problem encountered by women entering engineering education. Some speakers said that a fuller participation of women in engineering careers was vital, not only in terms of fuller utilization of their capability, but in terms of the humanizing effect that they brought to the jobs, the work place and the social processes at large. Amongst constraints mentioned that still operate against fuller participation of women were: differential wages and salaries, hardships involved in the job, other cultural factors whether at the conscious and sub-conscious levels, and lack of training facilities and training support. The Indian Action Plan for Women was mentioned, in which the measures taken included identifying occupations where women's participation was not satisfactory and should be actively supported; organizational involvement of women in recruitment, promotion and other committees; training; and creation of specific opportunities. It was emphasized that participation of women in education was high in some countries; in Egypt, for instance, 30% of engineering students were women. In many countries, however, the number of practising women engineers was still negligible, but in most of these instances it was increasing. Steps should, however, be taken to promote women not only as engineers, but also as technicians. There was agreement that not only should the barriers in the way of women participation in engineering and technical occupations be overcome, but that active educational training and employment support should be given within the context of the social and cultural conditions.

Agenda item 4(b): Curricula design, including teaching and learning processes, generalized curricula design, educational technology, rôle of research and project work, and evaluation

68. The Commission unanimously elected as its Chairman Dr. O. A. Ajayi (Nigeria), as its Vice-Chairman, Dr. A. F. Kaddou (Iraq), and as its Rapporteur, Professor L. V. Abis (Philippines). The background documentation for the discussion included the annotated agenda (SC/TECHED/4), the paper "Curriculum design in engineering education - progress report of the Unesco Working Group" (SC/TECHED/MISC. 2), and the paper by Mr. L. S. Chandrakant entitled "Current issues in technician education in developing countries" (SC/TECHED/MISC. 10).

69. The first session was devoted to discussion on the value of a systematic approach to the design of engineering curricula and the characteristics which any methodology of curriculum design had to possess in order to be accepted and used. Several participants described methods of curriculum design which were currently being developed and applied and which, in spite of differences in terminology and emphasis, could be related to the methodology presented to the meeting in the progress report of the Unesco Working Group on Engineering Curriculum Design. During the initial discussions, several speakers emphasized the need for a continual and fundamental review of all engineering curricula in order to ensure that the true and total needs of any situation were established and met. The diverse range of situations to be catered for in the present rapidly changing socio-economic and technological conditions were also referred to and illustrated by examples from many countries.

70. Other facets, raised by more than one speaker, which received the general approval of the Commission included the importance of engendering and fostering creativity and social awareness in all engineering students, the need for a detailed review of available resources at the outset of curriculum design process, and the part to be played by students and employers. Problems

involving the availability of personnel capable of devising an appropriate curriculum were discussed and it was generally agreed that a desirable feature of any proposed methodology of curricula design should be its potential to assist and educate those involved in designing new courses.

71. Some participants presented detailed syllabuses to the meeting in order to demonstrate a modus operandi and specific features which had been identified and catered for. These sample curricula included specialized courses related to modern scientific and technological developments and illustrated how to satisfy the need to integrate these courses harmoniously into an overall educational system and achieve flexibility. The importance of standardization was raised by an observer from the International Standards Organization (ISO) who suggested that an element on standardization as outlined in ISO Guide 9 should be included in all engineering curricula.

72. Several participants drew the attention of the Commission to the question of the optimum length of any undergraduate course. Although the Commission accepted that the duration of study was governed by a variety of factors, including the nature of the course, the industrial arrangements and how soon the graduate was required to operate effectively in his subsequent employment, a consensus view emerged that it was necessary for any proposed systematic curricula design method to include guidance on this question.

73. The desirability of incorporating flexibility and student choice into engineering curricula was also raised and discussed. The development of modular course structures, minor and major options and the reservation of a number of hours each week at some stage in the curriculum were advocated as means of providing students with some freedom to structure individual programmes or to transfer between courses.

74. At the close of the first session the Commission agreed that a methodological approach to the design of engineering curricula was feasible and offered the highest possibility of designing curricula to meet the real needs of the diverse and rapidly and radically changing contexts in which they were to operate. Diverse views were expressed concerning the methodology developed by the Unesco Working Group and used as a basis for the discussion. Whilst welcoming and accepting the philosophy and method advocated, the Commission felt that further development was necessary in order to complete the methodology and provide additional assistance and data to accompany it.

75. The Chairman then directed the Commission to consider the matter of the relationship between curriculum design and teaching and learning methods. The discussion on this topic ranged over the various methods of teaching adopted in engineering courses including project work, design studies, group approaches, self-paced instruction, and the use of computers. Several speakers emphasized the crucial and close relationship between teaching methods and course content and structure; this was agreed by the meeting which also accepted the importance of monitoring and evaluating the teaching methods and in particular of recording student reaction.

76. Further discussion took place on the possibility of matching the chosen teaching methods to the skills and attitudes to be developed in the student and the knowledge to be acquired and applied. For example project work and design studies appeared most appropriate at the development of personal characteristics, attitudes and skills whereas self-paced learning and individual studies were possibly more suitable for the inculcation of knowledge.

77. After considerable discussion, the Commission agreed that at present it was not possible to identify a definitive and formal correlation between curriculum design and teaching methods but it recognized the importance of this topic and wished to encourage and support further studies.

78. The Commission then moved to a discussion of the special problems involved in curriculum redesign and evaluation. The contributions to this discussion clearly established a common view that although redesign might not be as difficult and long term as the design of a totally new curriculum, it was still essential to follow a systematic procedure in order to ensure that the true needs were established and satisfied.

79. The evaluation of curricula was discussed at length and it was agreed that employers, educators and students each had a rôle to play. Employers could measure the success or otherwise of any curricula in terms of their assessment of the quality and performance of graduates. In addition many companies with special expertise and information on future planning and developments could provide data which could be used to make a significant direct contribution to the evaluation of any proposed curricula design. The need was emphasized for educators to monitor continually the curricula and it was suggested that some positive steps should be taken to encourage

and assist this by providing examples, case histories and other data in support of the curriculum design methodology and by making positive efforts to disseminate the appropriate information.

80. On the question of who should be involved in curriculum design, the consensus was that the faculty, student and industry should be involved. There was lengthy discussion on the depth of involvement of each of the above elements, and it was felt that the faculty and the specialist curricula designers were primarily responsible, with the students and industry serving as feedback sources on the suitability and effectiveness of the curriculum. These feedback data might serve, depending on their reliability, as an information source in the interactive process of curriculum revision or redesign. It was suggested that information on the needs of industry should be viewed with caution, as it might give undue emphasis to components of immediate value, at the expense of the basic scientific background necessary for the long-term professional development of the student.

81. Students also had an important part to play in curricula evaluation both during their studies and their subsequent careers. Participants presented and discussed views and experiences related to the evaluation during curriculum design (formative evaluation) and the monitoring and assessment of the curriculum in action (summative evaluation). The problems of the validity and reliability of evaluation were also discussed and in particular the need to relate views provided by employers and students to their particular solutions and preferences before drawing general conclusions.

82. On the question of monitoring and evaluating student progress, it was pointed out that in many countries students came from widely diverse backgrounds. Sometimes they came from minority groups and their schooling had been unable to give them adequate ability in the language used for instruction at the engineering or technician school.

83. There was a consensus that the curriculum should aim at producing an ingenious, creative, innovative and employable engineer who could collate, analyse and synthesize information, and use indigenous resources to improve and uplift the quality of life in his country. He should be capable of planning and of relating technology to the societal needs.

84. On course content, in general terms, it was pointed out that it would be desirable to inject aspects relating to:

entrepreneurship
awareness of environmental factors
national long-range development plans
anticipated futurist technological developments
philosophy of education.

85. Furthermore, on course content, it was suggested that the rôle of the teacher be re-examined. Some participants maintained that courses now should be formulated so that the teacher becomes more of a stimulator than the primary source of information.

86. The advantages of interdisciplinary or multidisciplinary approaches to education were pointed out. Sports and extra-curricula activities of students were also mentioned as an important component in education.

87. On the other hand, one speaker stressed that developing countries with industrialization programmes often needed technicians and also engineers with a high degree of specialization and motivation in narrow but important fields. The examples that he quoted included toolroom work, maintenance, plant engineering, quality and process control, and fuel efficiency.

88. In discussing the special problems of curricula for technicians, the Commission agreed that the same systematic approach was advisable. It should be recognized, however, that in many countries technician training was in a phase of rapid transition, and that there was great diversity between curricula used in different countries, and even between those used, in the same region.

89. Several participants stated that for technician training to be effective, the curricula must be designed and continually redesigned in very close co-operation with industry and other employers, so that the graduating technicians are immediately useful in industry.

90. Some speakers referred to co-operative technician training schemes, with students coming on a part-time basis from industry or having extensive or carefully planned training periods in industry during their course. It was agreed that practical training and project type work should

be a shared responsibility between education and industry, carefully interwoven into the other parts of the curricula.

91. One point seen as being important for the motivation of technicians and the image of technician careers was that the opportunity should always be available for technicians of outstanding ability to further their education and, for example, qualify as engineers or attain high management positions.

92. One participant mentioned that more technician training needed to be done in local languages, and that technician teaching materials should be adaptable into these languages.

93. Throughout the discussion it was clear that participants felt the need for guides and other material that would be of use to those frequently involved in curricula design or revision. It was suggested that the Unesco Working Group on Curricula give priority to the preparation of such material.

94. It was apparent from the discussions that very few countries had personnel experienced in curricula design for engineering and technician programmes. This was especially true for the developing countries, where there were at present the greatest needs for imaginative curricula design. Thus Unesco and the regional engineering associations should be active in developing co-operation in this curricula design area.

Agenda item 4(c): Social and environmental considerations in the education and training of engineers and technicians

95. The Commission began by electing its officers, choosing Professor H. Knepler (U. S. A.) as its Chairman, Dr. A. El Erian (ARE) as its Vice-Chairman, and Dr. N. Ovesen (Denmark) as its Rapporteur. The background documentation for the discussions included the annotated agenda (SC/TECHED/4), the Secretariat paper "The environmental education of engineers" (SC/TECHED/MISC. 3) and the report of the joint FEANI/Unesco seminar, held in Stockholm from 1 to 3 March 1976. Reports were also available on the meeting of the Interdisciplinary Working Group on the Environmental Education and Training of Engineers, held in Paris in September 1975, and the Unesco/UNEP pilot programmes in the Philippines and Venezuela.

96. A list of key questions had been devised and circulated at the start of the meeting. The discussions opened with the first of these, which suggested that the effective introduction of the humanities and social sciences into engineering courses had presented problems for a number of years. Various arrangements had been tried, with only limited success. The new emphasis on environmental issues and problems, however, seemed to offer an opportunity to relate such studies more effectively to the main stream of the engineering curriculum. If such a conclusion were acceptable, the Commission had one field of discussion and not two. This suggestion was unanimously accepted. The discussion turned, however, to a point of considerable significance which recurred several times.

97. Early in the session a speaker referred to engineering as culture-specific, meaning that all engineering activity reflects the values and thought-processes, as well as the physical environment and resources, of the society in which it takes place. This assertion was immediately contested by a participant from a developing country who regretted that a great deal of engineering education, even in countries such as his own, tended to reinforce the idea that all engineering was of Western origin. The engineering taught certainly was culture-specific but specific in some cases to an alien culture. This point was elaborated by a number of speakers and there was general agreement that engineering students in Africa, the Middle East and Asia should be led to an appreciation of engineering achievements, at any stage of history, within their own respective cultures.

98. The corollary was put forward, that engineering students in Western countries also should be made aware that the values embedded in their technology are mainly Western values and not globally acceptable or appropriate. In both developed and developing countries engineering must be revealed to students as an activity which should be responsive to local needs and the indigenous cultural heritage.

99. The emphasis on regional considerations served to introduce a conclusion in the report of the Unesco interdisciplinary working group that Unesco promote the establishment of regional networks in this field. The reasoning behind this was explained as follows: firstly, environmental education, affecting attitudes and awareness, calls for active learning by engineering students; secondly, this type of learning depends for its effectiveness on a variety of special resources, mainly of an informal nature; and thirdly, such materials are not generally available

in a form which makes them suitable for engineering education, and their production is hampered by the considerable time and effort required and the need for expertise and flair which is not always to be found in engineering schools.

100. The network idea is that groups of institutions within a region having a common language and cultural heritage might set up arrangements to share the production of informal learning materials in the environmental fields, disseminate such materials and instruct teachers in their use. It was emphasized by the Secretariat that although the suggestion emanated from a Unesco group, it should not be imagined that comprehensive funding could be made available from United Nations agencies. Unesco might be able to offer consultants and workshops in helping to set up such arrangements but the prime responsibility must rest with the institutions involved. Regional associations of engineers might have a major rôle to play in bringing such institutions together.

101. One participant expressed criticism of a reported tendency of Unesco to rely on consultations with global agencies and non-government organizations. It was suggested that such bodies failed to reflect regional and cultural considerations to a sufficient extent, and that Unesco should direct its consultations more towards the regional and national bodies, particularly in engineering, referred to above.

102. At various times in the discussion, participants referred to the need for non-engineering teachers from various disciplines to participate in environmental education of engineers. It was felt that service teaching was frequently unsuccessful, for a variety of reasons. The preferred arrangement, it was considered, was one in which such specialists were fully integrated members of engineering schools. In this connexion many speakers referred to the need to ensure that such specialists had career opportunities which were sufficient to ensure that their contribution to engineering was fully committed and capable of developing over a period of years.

103. The transdisciplinary approach to environmental education has a direct bearing on curriculum. A speaker referred to the parallel session on curriculum design and said that the concept of design was deeply embedded in engineering, hence the use of the term in the Conference. However, the engineer did not normally include himself in what he designed. The engineering teacher was an important part of the curriculum and unless he really thought it possible to redesign himself he could only view the curriculum as something to be developed rather than designed.

104. It was further commented that in a process of curriculum development and refinement, and particularly where transdisciplinary studies were required, student projects had an important part to play. Real life environmental problems in their complexity, put the focus on the curriculum and the need for changes. They also put the focus on the rôle of the teacher, whether in engineering or another discipline. If he could offer insight and knowledge to the solution of a real life problem in the field of engineering he would acquire status in the eyes of his students. If he could not, his own need for development was clearly revealed. It was suggested that projects had a great deal to offer in curriculum development.

Agenda item 4(d): Continuing education in engineering fields, including objectives, mechanisms, and relationships with initial education and with employment

105. The Commission began its work by unanimously electing as its officers, Dr. S. Al-Nassri (Iraq) as Chairman, Professor John Klus (U. S. A.) as Vice-Chairman and Professor C. S. Jha (India) as Rapporteur. The background documents for the discussion included the annotated agenda (SC/TECHED/4), the Secretariat paper "Continuing education of engineers and technicians" (SC/TECHED/MISC. 4), and the report of the 1975 meeting of the Unesco International Working Group on the Continuing Education of Engineers.

106. The Commission discussed in depth the objectives and the requirements of continuing education programmes for engineers and technicians, and members exchanged information about the various programmes being run in the different countries. There was unanimity of view on the need for continuing education at all levels of the profession, and for an integrated approach to the planning of the initial and the continuing education programmes. While initial education should emphasize the fundamentals of scientific and technical knowledge, continuing education should enable engineering personnel to keep up to date with advancing technology and provide educational inputs for professional growth throughout their careers. Continuing education needs were not limited to technical subjects, since the acquisition of engineering judgement and management skills called for education in such diverse fields as productivity, finance, economics, safety, psychology, human relations, and management.

107. The different rôles of educational institutions, industry and professional societies in the organization and monitoring of continuing education programmes were discussed in detail and it was felt that very close collaboration among the three was desirable for the proper planning and implementation of these activities. Professional and learned societies and other suitable organizations which brought the educators and the practising engineers together were well suited for co-ordinating all continuing education activities, as also for the dissemination of information about them.

108. It was agreed that continuing education through the traditional method of on and off campus courses of short and long duration might not be able to meet the ever increasing and diverse needs for continuing education at all levels of the profession and full use should thus be made wherever possible of the non-traditional methods available, such as correspondence courses, instruction through radio and television, satellite links, video cassettes, and programmed learning. The inherent dangers of lack of quality control and inadequate feedback in some of these non-traditional methods were recognized, but it was felt that they could be minimized by proper planning. The possibility of sponsoring a global study for assessing the cost-effectiveness and the teaching efficiency of the various educational techniques used in continuing education of engineers and technicians was discussed in detail, but it was felt that studies at national and regional levels would be more useful in giving guidance in the selection of the most appropriate technique in a given situation. It was further recommended that the results of these studies should be widely disseminated.

109. There was discussion in detail on the need for identifying one, or more, organization in every country which would have the responsibility of collecting and disseminating information about continuing education activities within the country. It was recognized that such centralized national agencies could be used as channels for regional and international co-operation in the field, and there was unanimity that such identification of centralized agencies be made. Some participants recommended that this responsibility be given to a professional society while others considered the Ministry of Education, or industry, or an institution of higher learning more suitable for this function. It was felt that the centralized organization given this responsibility should have an independent authority and be solely concerned with the continuing education needs of engineers and technicians.

110. The question of setting up specialized centres for continuing education in every country was discussed. Some speakers argued that such specialized centres would be very useful as they could develop special programmes to meet the needs of individuals, groups of individuals, and organizations. The Wisconsin, U. S. A., model was cited as an example and it was felt that such an institution located in a university campus might meet broad training needs very effectively. Other participants, however, felt that since the continuing education needs of engineers and technicians were so great, facilities should be created, and expanded where they existed, in all institutions and industrial establishments capable of running such programmes.

111. Many participants discussed the desirability of establishing proper linkages and interaction between the initial education and continuing education systems. It was often the case that engineers engaged in teaching, research and development were generally up to date, as they continuously educate themselves through self-study. It was felt that enough training should be given during initial education in the techniques of self-learning, self-improvement, information location and technology adaptation. Such a training would motivate engineers, after their formal education was completed, to take full advantage of continuing education programmes. It was also appreciated that educational material for newer technologies, first developed through continuing education of engineers and technicians programmes, would need subsequent integration with initial education courses. Dynamic linkages between the initial education and continuing education programmes should be an essential feature of all educational systems, and both should henceforth be regarded as forming a single unit of life-long education.

112. The desirability of following the example of the French law of 1971 that makes support of continuing education of engineers a legal liability of the employers was discussed at great length. While many welcomed such a legislation in that it would give every engineer and technician a right to professional development through continuing education programmes, others felt that legislation in these matters would be a hindrance rather than a help. There was, however, unanimity that every encouragement should be given to all employers to expand continuing education facilities for their employees. It was finally agreed that Unesco should bring to the notice of all Member States the French law of 1971 and recommend that fiscal and statutory incentives be given to industry to encourage participation of their employees in continuing education programmes, with the aim of ensuring better productivity and more effective utilization of manpower.

113. The status and importance of technicians in the national context was discussed at great length. It was recognized that higher technicians played a very important rôle in national building, but in many countries their status and emoluments were not in keeping with their contribution to industrial growth. Many delegates stressed the need to have parallel streams of professional development for engineers and higher technicians. The examples of the U. S. A., Federal Republic of Germany and the German Democratic Republic were cited where separate degree programmes were available for both categories. Some delegates thought that professional development should not make a higher technician into an engineer, arguing that this would deprive the industry of the benefits of the technician's expertise. Programmes run by universities and by professional societies to cater for the needs of higher educational qualifications of technicians were described by many members. After much dicussion it was agreed to recommend that adequate recognition should be given to the rôle played by technicians in national development. Opportunities should be given to them for professional development both through specially structured formalized on-campus programmes and through continuing education programmes. The salary and status of engineers and technicians should be commensurate with the professional competence and contribution of each category rather than with their formal educational qualifications.

114. There was some concern that the special needs of continuing education for teachers of technical institutions were not fully recognized. It was mentioned that continuing education should be available to all engineers, including teachers, but special programmes for teacher education should be included in any recommendations for staff development and institution building. The experience of several countries, including India, in the field of faculty development for engineering institutions was considered worthy of note.

115. There was some discussion on the desirability of exchange of technicians between the Member States. It was felt that such exchanges would be of mutual benefit, and would improve the skill and the effectiveness of the technicians. There was unanimity that a list should be drawn up of industrial establishments in every country which would like to join this programme, arrangements for the exchange being left to Unesco.

Agenda item 4(e): Education-industry interaction in technological education, in industrialized and developing countries

116. The Commission began by unanimously electing Dr. S. E. Chukwujekwu (Nigeria) as its Chairman, Professor H. Kikkawa (Japan) as its Vice-Chairman, and Dr. E. Shishov (USSR) as its Rapporteur. The annotated agenda (SC/TECHED/4) served as a basic document for the discussion.

117. The Chairman in his opening remarks, and many of the participants during the course of the discussion, emphasized the fact that interaction between education and industry is regarded as a vital necessity for the education and training of engineers and technicians and not merely optional or desirable. It was also generally agreed that co-operation between education and industry should be regarded and arranged as continuous interaction. In the longer term, society as a whole stood to benefit if education was thereby improved and if industry was stimulated by such co-operation and was able to recruit better qualified and better motivated personnel. However, the discussion showed that there still existed a number of serious problems affecting the efficacy of education-industry co-operation.

118. From the general discussion it was obvious that in order to educate an engineer or a technician able to participate actively in development, curricula should be geared to actual development needs in such a way that students during their studies took an active part in solving real engineering work situations. However, the discussion showed that in some countries this was not the case. Often, curricula were brought from abroad and not suited to local conditions. As a result graduating engineers had mainly theoretical knowledge and the research activities at universities were usually not industrially oriented.

119. On the other hand, some participants expressed deep concern about the urgent need to strengthen the links of communication between industry and education. Some of the normal links such as consultancy, which proved to be efficient in developed countries, might have negative results if simply transferred to other countries, for example teaching staff might do routine work as consultants only to obtain more money. Several participants emphasized that informal personal contacts between teaching staff and personnel in industry were an efficient means of facilitating co-operation.

120. It was pointed out that in many countries consultancy centres attached to university engineering schools were successfully used to channel education-industry co-operation. On technician level, production plants and testing units were suitable forms of co-operation, and might also be handled through such consultancy centres or liaison units.

121. The point was strongly made and generally accepted that industrial experience of teaching staff should be a necessary part of their qualifications. It was repeatedly pointed out that institutions needed the co-operation of industry to ensure that their teaching staff were fully aware of local industrial problems and able to illustrate their teaching with practical examples. To this end, the administrations of universities and other institutions should encourage staff to spend their sabbatical leaves in industry. Part-time teaching, part-time consultancy and industry-sponsored research might also be used. It was further suggested that institutions adopt reward and promotion systems that give industrial experience high recognition.

122. One speaker maintained that the key to effective co-operation was to have teachers who had served for considerable periods in industry and thus were eager to maintain their contacts. He proposed that when making staff appointments, institutions should give preference to applicants from industry, rather than promoting teachers who had only academic experience.

123. Another participant stressed that periods in industry for teaching staff should be carefully planned and not be ad hoc sabbatical leaves or industrial residence. He also maintained that from a pedagogic point of view some types of outside consulting work done by teaching staff were worth while, but that much highly specialized consultant work was useless.

124. On the other hand, practising engineers invited from industry were often not acquainted with new achievements in engineering and modern technology. To up-date the knowledge of industrial engineers, educational institutions should organize refresher courses. Industry should be prepared to release its own personnel and to accept academic staff for periodic industrial experience.

125. One difficulty that was mentioned when discussing sabbatical leaves in industry of teachers was that they usually had a strong urge to publish the results of their work, whereas industry was often secretive and did not always make publishing possible.

126. Difficulties in organizing good practical training of students in industry were emphasized. Many participants stated that graduating engineers and technicians often had inadequate practical knowledge. To improve practical training of students during vacation periods or as part of sandwich-type courses and for project work in graduate training programmes, staff colleges for training officers in industry and institutions might be established. It was also underlined that when training officers were appointed in industry, they should, wherever possible, have had some teaching experience and have had previous contact with students. There was strong criticism of teaching staff who did not visit their students in industry.

127. The costs of various aspects of co-operation were discussed. Student training, their supervision while in industry, the provision of workshop and testing facilities in institutions, the payments involved in staff exchanges, and recruitment of replacements were mentioned. One participant pointed out that cost was a major deterrent to co-operation, although other participants indicated that much could still be done without incurring additional costs and, in some instances, co-operation could be self-supporting. Several speakers described financial arrangements for consulting and testing services carried out by engineering schools, one example being for one-third of the revenue to go to the university administration, one-third to a fund to cover actual expenses, and one-third to the participating staff.

128. There were a number of requests for Unesco to take further action in this field, through its International Working Group on Education-Industry Co-operation and otherwise. Amongst those mentioned were guidelines for co-operation, criteria for industrial training for teaching staff, dissemination of case studies, regional courses for training officers, and check lists of possible areas in which institutions in developing countries could help small industry.

129. It was suggested that M. Sc. students should in general be discouraged from purely theoretical studies and should instead be asked to do projects of a practical nature that concerned local problems.

130. It was also pointed out that industry was often also short-staffed and usually so busy with production matters that it found co-operation with education difficult. Thus incentives and legal obligations might need to be provided by governments. One participant pointed out that large-scale industry found it much easier to co-operate than did small-scale industries, yet the latter probably stood to gain most.

131. Along the same lines, another speaker pointed out that in some developing countries there were large industrial corporations which did not ask for any help from educational institutions as they had their own self-sufficient training and research programmes. Mining and oil

exploration were two fields where this was often the case, and where foreign ownership or management of the industry was sometimes a further complication.

Agenda item 4(f): Institution-building in technological education, including educational systems, management, and physical facilities; staff development policies and problems. Student selection, guidance and motification

132. As its officers, the Commission unanimously elected Professor R. P. Patel (Kenya) as Chairman, Professor H. Khakzar (Iran) as Vice-Chairman and Professor A. M. B. Sankies (Guyana) as Rapporteur. As background material for its discussions the Commission used the annotated agenda (SC/TECHED/4) and the paper prepared by a Unesco consultant, John McNown, entitled "Development of teachers for engineering schools" (SC/TECHED/MISC. 6). The report of the symposium held in Dar es Salaam in December 1974 on Staff Development in Engineering Education was also available to the participants.

133. The Commission divided its work into three sessions dealing with staffing; educational systems and management of institutions; and physical facilities and students. The summary of discussions is thus presented in that order.

134. Opening speakers stressed the need for both institutional planning and career planning for individual teachers. Conflicts could arise between these two needs and make it necessary for plans to be reviewed and revised frequently. Areas of special concern that were mentioned were the teacher's experience with local engineering practice and his knowledge about pedagogical methodology and learning theory. In developing countries the complementary rôles of expatriate teachers and local staff continually changed. Prolonged stays for study abroad and extended research experience were often not conducive to a reintegration in the technological environment of the less developed countries.

135. The problems of staffing started with recruitment and training. India focused on the development of Institutes of Technology to provide leadership and training of future teaching staff for other institutions and also organized short courses and summer courses for upgrading the level of staff in existing engineering schools. Special courses were arranged for training technical teachers.

136. An important difficulty described as existing in many countries was the lack of sufficient inducement to cause well-trained engineers to leave good jobs abroad and return to their native lands. Some participants maintained that these people would return if they were offered positions commensurate with their abilities, and if an effort was made to create an environment conducive to effective academic work. One problem often mentioned was the continued existence of previously imported teaching systems that had not evolved and thus appeared completely outmoded to young well-qualified teachers returning from study abroad.

137. A special point was made by several participants concerning the need to relate salaries in academic institutions to those prevailing in industry. Some countries reported success in obtaining a differential increase for engineering teachers over salaries for teachers in other university faculties, such as science and liberal arts.

138. Much of the discussion centred on the question of the acquisition of practical experience by engineering teachers. Questions raised included the kind of experience, when it should be obtained, whether in home countries or abroad, how it could be financed, and how to reflect its importance in the system of awards in the educational system.

139. Some participants proposed the creation of production centres and consultant groups which would form part of the engineering or technician schools. These would undertake all kinds of tasks to aid government, small industry, agro-business, the small farmer and local consultant offices. Through these centres, students should be involved in specific tasks in summer employment or in project courses, and the experience and problems encountered would also be incorporated in the classroom.

140. Others insisted that full-time experience in industry was essential. The appropriate duration was recommended as being from two to five years. One participant noted that the staff at one professionally oriented Canadian school had an average of 11 years of practical experience, whereas in many other instances the average in a school or department might be as low as a few months. To be meaningful, such experience had to be renewed through consulting work or subsequent leaves of one or two years.

141. Several participants pointed to the difficulties that such a policy entailed. If a class was to be taught, it had to have a teacher at once, not the prospect of a future teacher who would return as a better teacher after a few years of practice. Use of the sabbatical leave was urged but sabbaticals were now generally used for trips abroad to learn of new developments and to conduct or complete research projects. The present academic value structure did not encourage staff to forsake this pleasant and stimulating experience for a routine industrial job which might be more or less rewarding.

142. The "publish or perish" syndrome was noted. How could an educational institution evaluate professional experience and take it into account when deciding on salary levels and promotions? Also, few countries had systems which permitted, let alone encouraged, any sort of exchange between industry or government and a teaching institution. Even teachers of technicians usually acquired their experience before teaching, not after they had begun their teaching careers.

143. Programmes were proposed for training teaching staff locally. In Africa, a network of schools proposed to have each school specialize in one or two areas and exchange students and prospective staff in such a way as to provide, in the African environment, advanced study and keep costs of training to a minimum.

144. The system in francophone countries, like that in France, utilized a continuous stream of practising engineers as part-time teachers. In this way co-operation with industry was assured, although sometimes at the cost of reduced research activities.

145. The rôle and importance of technicians were mentioned, especially in connexion with industry and with specialized service installations such as hospitals and power stations. Some participants said that too many engineers were doing the work of technicians but at a high salary. Many stated that technicians should receive higher salaries and recognition or should be awarded a special type of degree.

146. A part of the discussion centred on how to help teaching staff make courses suit local conditions. It was clear that many participants felt that at present they did not. Suggestions included a better definition of the graduate to be produced, closer ties between employers and teachers in planning courses, special courses in management, as well as closer ties between local projects and classroom work.

147. Short courses, seminars and special publications were proposed to provide pedagogical knowledge. Help should be available from faculties of education. It was suggested that Unesco could help plan and support regional seminars on pedagogy for young teachers.

148. Numerous outside influences were said to adversely affect the development of sound engineering programmes. The universities themselves, government policies, and attitudes of multinational corporations were stated as sometimes having adverse effects. Problems and solutions described by many speakers had many common features, and it was clear that some countries had found ways around most of them. Examples included raising of salaries for engineering teachers, increased income from production and consulting services, changes in government policies with regard to leaves and special assignments, and a reduction in the importance given to the Ph. D. degree.

149. Educational systems and management of institutions were discussed from various points of view. The discussion centred first on the structure of institutions and especially on faculty relationships in university level establishments. It was agreed that there was a need to break down the barriers between faculties of engineering and such faculties as economics, commerce and sociology. This breakdown was necessary because an interdisciplinary approach to many problems of an industrialized or industrializing society was necessary if they were to be solved. The modern world was faced with environmental problems, production problems, energy problems, population problems and so on, in seemingly endless number, and if engineers were to play a part in solving them it could only be in co-operation with professionals of many other disciplines. The barriers between disciplines had to be broken down in teaching institutions if their graduates were to co-operate meaningfully when they left. No participant could describe any one, sure, method of breaking down these barriers, although it was agreed that general awareness of the problem was essential. Therefore, Unesco should play a part in publicizing the interdisciplinary types of problem that industrialization seemed to present to society for solution by engineers and others.

150. Although the topic of an interdisciplinary approach was discussed mainly in terms of engineers, the technicians were not forgotten and participants took care to point out that technicians, and especially higher technicians, could be involved about as much as engineers

in discussing problems which related to the effect of industrial enterprises and their products on the life of man.

151. From a concern with the breaking down of barriers in institutions the Commission turned to the ever-present question of specialization versus non-specialization in curricula. It was soon evident that there was no one answer to this question. An approach which was correct for one institution and one country was not correct for another. There was, however, a generalization of some kind to be discerned. In the least developed countries, and possibly in others, the identification of needs was relatively easy as they were clear and did not need a sophisticated instrument to be uncovered. Furthermore, these needs, when classified, fell into a rather small number of classes. Thus, it was argued that when needs were clearly identified it was educationally and socially efficient to give specialized courses to engineers and technicians who would then fill the known vacancies. It was also argued that in other circumstances the students should, by means of optional courses, courses arranged in modules, and so on, be able to choose a course suitable to their aspirations and that nevertheless society's needs would still be satisfied.

152. Other speakers suggested that even inside faculties of engineering and technical colleges there was room for innovation in groupings chosen for, or by, the staff. In some countries, for example, a chair of public works engineering might be far more appropriate than a chair in structures and a chair in hydraulics. Other examples were given and most participants agreed that engineering and technical institutions might often gain by having an internal structure that reflected or matched the structure of local industry. Indeed, throughout the session the concept of matching the needs of the industrial society and its industries by creating a problem-oriented institution structure was in the forefront of the minds of many participants.

153. Some examples of such an educational structure were given but it was noted that they were usually ad hoc arrangements imposed on an existing, more traditional system. As such they caused problems of their own. Teaching personnel, often for reasons arising from outside the institution, wished to identify themselves with a discipline or an organized group which did not exist inside the institution. In spite of these known difficulties, and others touched upon briefly, the Commission agreed that institutional structures had to be changed or organized to suit the local situation. Indeed, one participant argued that in his experience there were often too many departments in an institution, leading to time-wasting administrative problems, promotional problems, empire-building and duplication. There was considerable support for this view.

154. Considerable support was also given to a proposal that short courses and medium-length courses in institutions for engineers and technicians should be interdisciplinary in character. Very few problems in industry today could be classed as purely technical problems. In almost every case the solution, to be feasible, would involve consideration of economic, technical, manpower, environmental and sometimes social aspects. Hence the most relevant of the courses would also be multidisciplinary in character, enabling the students not only to find out how to do things but also to discuss what to do.

155. There is probably no single optimum method of managing and organizing an educational system and the session did not find one. The Commission was in complete agreement that an engineering and technician education could be a true educational process illuminating the mind about the modern world, and that this function would be enhanced if more activities were spread over or combined with the so-called conventional disciplines.

156. The next major question before the Commission was the physical facilities required by institutions to carry out their functions. It was agreed that only after identification of needs could an educational system and its required facilities be designed and built. Therefore, it was emphasized again that a country or State or province had to have some mechanism for the identification of needs in engineers and technicians. Various successful methods existed and it was an area in which Unesco should devote more effort, including outlines of experiences.

157. Once physical facilities were needed then the usual step was for an institution to ask for funds so that it could acquire the buildings and equipment it appeared to need. For an isolated institution there seemed no alternative to the costly business of setting up a full range of facilities. Many participants pointed out, however, that where two or more institutions were adjacent, or one or more institutions in an industrialized town or region, there were then other possibilities.

158. For example, experience in Indonesia was quoted whereby several technical equipment centres with instructors each served five technical schools, thus considerably reducing overall equipment costs. The equipment was used very fully, the centres being staffed on a

shift basis and open from morning until evening. The concept was suitable for populous areas but had certainly many advantages and the session noted this information with great interest. Obvious but minor pedagogic disadvantages would not outweigh the advantages, especially for a country short of monetary resources or teachers.

159. Several participants supported a procedure whereby a contract of some kind was arranged between an institution and some local enterprises so that students could use expensive equipment or machinery not likely to be purchased by the institution. Where this had been done with success, students, under careful supervision, were admitted to the enterprise in the evenings to carry out industrial type work or tests.

160. The session noted that in one country a study was being made on the possibility of reducing the costs of equipment needed in technical teacher training institutes. In these institutes quite expensive apparatus was often bought but was under-utilized or unnecessary. It was suggested similar studies would be useful in other countries.

161. It was stated that often home-made laboratory equipment was cheaper and educationally more efficient than apparatus bought from commercial sources. It was agreed that this was sometimes true, although much more equipment specifically designed for teaching purposes was now coming on to the market. A plea was made for more information on the design and construction of cheap engineering laboratory apparatus, and it was suggested that journals of engineering education accept and publish more material of this type.

162. Consideration of physical requirements included both equipment and buildings. Unesco was urged to continue its publications on the basic design requirements for laboratories and workshops in various specializations. These publications, the Commission agreed, should include space requirements, service networks, power requirements, drainage, floor loadings and other relevant matters. The information should, if possible, be illustrated by examples of successful layouts. The equipment schedules associated with each laboratory should be as detailed as possible.

163. Throughout the discussion of physical facilities, and indeed in the preceding discussion of educational systems, the question of the cost of educating an engineer or technician arose again and again. Many participants were anxious to find a way of estimating the benefit of a given expenditure of money on an institution. It was realized, of course, that at best such an estimation could only give an approximation. Nevertheless, many participants, either to compare similar institutions in one country or to estimate the educational efficiency of their own institution, wished for guidelines to help them in these studies.

164. It was appreciated by the participants that education implied providing a person with something more than mere training - the provision of ideas enabling him to understand the world he lived in. Engineering and technician education should therefore provide a host of tangible and intangible benefits and thus was a sound investment. However, some way of estimating cost-effectiveness was still thought desirable and Unesco was urged to make a study of this matter.

165. Much discussion finally centred on the maintenance of expensive equipment. The Commission agreed that Unesco should be urged to continue its efforts in helping to set up national centres for the construction, maintenance, repair and calibration of scientific equipment.

166. The final topic considered by the Commission was student selection for engineering and technician institutions. Students could only be selected from the group which presented itself for selection and was thus motivated in some way to try to become engineers and technicians. Candidates for selection themselves fell into two groups, one being the group leaving some type of secondary school and the other being the group already working in industry and attempting to upgrade its qualifications. It was possible that the second group was usually the most highly motivated. It was also possible that this second group was artificially restricted in many countries, but in any event it was normally smaller than the first group. The first group was also motivated, but participants expressed doubts as to whether a mere application indicated an aptitude for engineering or technical work.

167. In many countries, an engineering or technician qualification led to a very good job and this in itself could motivate many applicants. The Commission thought, however, that those who finally entered the institutions should do so from at least a basic knowledge of what engineering is about. Aptitude tests, wherever they could be used, could be very useful indeed but there were countries in which their use was not yet possible. Participants therefore concluded that, failing more rigorous entrance tests, all schools from which applicants were drawn should be fully informed about engineering careers. Career information should include details of work

done by engineers, the contribution to society which they could make, as well as career prospects. Further, the Commission recognized the importance of continuous guidance and counselling of students in institutions and recommended such practices.

168. One participant recommended that secondary schools should have hobby centres with workshop facilities in which students could make either assigned or chosen devices, or even devices designed by themselves. A school report on a student's performance in the hobby centre might be a useful addition to the results of his school leaving examination and complement or substitute for a normal aptitude test.

Agenda item 4(g): Co-operation in technological education at international, regional and country levels

169. The Commission began its work by electing Professor J. E. Jansson (Finland) as its Chairman, Dr. R. E. J. Butler (Ghana) as its Vice-Chairman, and Professor D. L. Mordell (Canada) as its Rapporteur. The background documentation for the discussion included the annotated agenda (SC/TECHED/4), and the paper entitled "Rôle of engineering societies and the profession in promoting improvement of technological education" submitted by the World Federation of Engineering Organizations (SC/TECHED/MISC. 8).

170. The Chairman began the discussion by reviewing the points covered in the annotated agenda. He asked for contributions on the objectives of co-operation and whether existing organizations and mechanisms were adequate to ensure that co-operation was effective.

171. There was general agreement that amongst the objectives of co-operation were the exchange of educational experience between all countries, the dissemination of information on innovations, facilitation of the exchange of teachers and students, and the transfer of knowledge to the less developed countries so that the well-being of their people could be improved.

172. Amongst the problems noted as impeding co-operation were the barriers of language; political and social barriers; expense; lack of mutual recognition of qualifications; and lack of means of communication regionally and internationally.

173. One proposal was that Unesco establish a list of highly qualified specialists in the engineering fields who would be able to assist developing countries as consultants. The difficulties of keeping a list of this type up to date were mentioned, and the Director-General's representative stated that the recruitment services of Unesco had a considerable number of files of potential consultants and were always prepared to help Member States in recruiting international staff.

174. The representatives of the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) described the activities of their organizations in the training of engineers and technicians in the special fields of their competence. The paper "The education and training of environmental manpower in connexion with health" (SC/TECHED/MISC. 15) was referred to by the WHO representative.

175. The need for strengthening channels of communication between organizations involved in technological education was emphasized by many speakers. It was suggested that Unesco disseminate information directly to societies for engineering education and the individual institutions. Newsletters were agreed to be an inexpensive and effective means of communication. It was also recommended that Unesco compile glossaries of the terms used with regard to education and training, so as to facilitate communication.

176. The rôle of professional societies was discussed, and it was noted that through the World Federation of Engineering Organizations (WFEO) and the regional bodies there was a good mechanism for co-operation. On the other hand, it was noted that whereas in the basic scientific fields the International Council of Scientific Unions (ICSU) was a very active body, the Union des Associations Techniques Internationals (UATI, Union of International Engineering Organizations) was relatively weak. It was suggested that efforts be made by Unesco to strengthen the activities and membership of UATI, so that it could cover all major fields of the basic and applied engineering sciences.

177. There seemed to be a consensus that regional co-operation was more effective and easier to arrange than world-wide co-operation. Reasons given included community of interest, common problems in research and training, relative small scale of activities that facilitates communications and meetings, and participation in activities that usually could be more representative. The work of Unesco in supporting the various non-governmental regional associations and in arranging teacher exchanges and meetings was strongly commended.

178. It was also suggested that sub-regional groups and activities should be supported, especially where there was a strong community of interest and where common languages facilitated co-operation. Several speakers pointed out that many academic people did not know what was happening in adjacent countries, or even what other institutions in their own country were doing.

179. The concept of regional networks of co-operating institutions received strong support from the Commission. It was pointed out that these needed to be supported financially to develop into effective mechanisms, so as to bring into contact all teachers and research workers working in similar areas. The exchange of training material and prevention of duplication in research were two important rôles envisaged for these networks.

180. A number of participants underlined that a country was able to co-operate more effectively in regional and international activities when national organizations were strong and representative. Unesco was asked to help its Member States to strengthen national societies of engineers and technicians, or national associations concerned with technological education.

181. The example of Japan was quoted with regard to its system for international co-operation and assistance at various levels, including the organization of training courses with international participation, exchange programmes of high level research personnel, and training programmes in Japanese industry for foreign engineers and technicians. The important work done by the American Society for Engineering Education (ASEE) was also mentioned.

182. One participant pointed out that opportunities for regional and international co-operation in technician education were very poor in comparison with those for engineering education, although the problems and needs were equally serious, especially for the developing countries. It was agreed that Unesco and other organizations should be requested to give much greater attention to technician training. Technician teacher training, administration and planning, retraining, and development of teaching materials for technicians were mentioned as being important.

183. Several participants mentioned the need for Unesco and other organizations to support, on a national and regional basis, activities aimed at training or retraining teachers. Use of modern teaching methods, and development of teaching material for environmental training were mentioned as examples of where regional action could be effective.

184. There was considerable discussion on means of enabling more teachers to work in other countries during periods of sabbatical or other leave. It was pointed out that many institutions in developing countries were desperately short staffed and would be glad to accept foreign teachers for periods of the order of one year or even less.

185. On the other hand, many teachers in industrialized countries were not only interested in teaching abroad for short periods but were able and willing to do so; however, very few mechanisms to arrange this were available. It was suggested that Unesco should explore the possibility of maintaining a register of offers and needs for visiting teachers. Another suggestion was that a similar scheme be elaborated so that teachers in the least industrialized countries could be sent to spend periods in industry in other developing countries in the same region, where their experience would be more relevant to their national environment.

186. During the discussion on priorities for future Unesco activities, consensus emerged on a number of points. The first was that regional activities should be promoted strongly, to improve co-operation between developing countries at similar stages of development. One aspect of this was the strengthening of facilities for post-graduate training in developing countries, so as to reduce the need for study in Europe or North America to obtain advanced degrees. It was further suggested that the research activities in these courses should be on problems related to local development needs rather than on topics related to research fashions prevailing in the highly industrialized countries.

187. Problems of the equivalence of diplomas were touched on during the discussion, and the work done by Unesco in drawing up regional conventions received favourable comment. The bilateral approach was also seen to be realistic.

188. Several speakers asked that Unesco help and also associate its name with more of the national and regional meetings that are held on various aspects of technological education. In many cases it was not a question of Unesco providing funds to cover all the costs and, in any event, it was clear that the Unesco budget was so limited that this could not be done - but if Unesco agreed to co-sponsor such meetings there was a better chance of obtaining financial support

from other sources and of having good participation. It was thus agreed by the Commission that Unesco be asked to consider favourably sponsorship of a larger number of national, regional and international meetings, seminars and courses concerned with technological education.

189. A number of speakers mentioned that international meetings with wide participation had many tangible and intangible benefits for participants and their home countries. It was suggested that the period of eight years since the 1968 meeting in Paris was too long, and that Unesco should organize another international conference within the next six years.

CLOSURE

190. During its final plenary sessions on 26 April 1976, the Conference discussed the reports presented by the Chairman of the commissions that considered agenda items 4(a) - 4(g), and the recommendations of these commissions. In each case there was active discussion of the recommendations before they were finally adopted by the Conference for transmission to the Director-General of Unesco.

191. The Rapporteur-General then gave a broad review of the work done by the Conference, highlighting its most important concerns. The text of this review has been included in the summary of discussions contained in this report.

192. The Conference then discussed these major concerns, identifying the most important areas for national, regional and international action by Unesco and its Member States. The Conference formulated and then unanimously adopted twelve recommendations of a general nature.

193. At the close of the meeting on 26 April 1976, addresses were given by its Chairman, Dr. A. Ramachandran, and by Dr. A. Evstafiev, representing the Director-General of Unesco.

RECOMMENDATIONS

194. At its final plenary session on 26 April 1976, the Conference endorsed the specific recommendations of the seven commissions appointed to deal with agenda items 4(a) - 4(g), and adopted twelve general recommendations addressed to the Director-General of Unesco.

195. These recommendations are as follows:

A. GENERAL RECOMMENDATIONS

As a result of a thorough discussion of the items on the agenda, involving a broad exchange of ideas among individual participants, representatives of other organizations of the United Nations system, representatives of non-governmental organizations, and observers, the Conference was able to formulate and unanimously adopt the following plenary recommendations to the Director-General:

1. The Conference recommends that Unesco should continue to promote and facilitate co-operation on a world-wide basis between those involved in the education and training of engineers and technicians, so as to share experience and stimulate reform and development of systems and institutions for technological education. In particular, the current Unesco long-term international programme in engineering education should be continued and expanded by supporting work in priority areas and by strengthening mechanisms for regional and international co-operation. The emphasis in this programme should be on the active involvement of all interested educational institutions, the organizations in the United Nations system, other governmental organizations, professional bodies, and non-governmental organizations of an international, regional and national nature.

2. To ensure a more equitable distribution of the present and future benefits of science and technology, it is necessary that all countries develop their own indigenous training and research infrastructures, able to select, adapt and create technologies in ways best suited to the needs of the country's society. The Conference therefore recommends that Unesco should give high priority to assisting Member States, especially the least developed, to create and strengthen their facilities for training and retraining technological manpower, so that they are able to make best possible use of their human and natural resources, and are in due course also able to contribute to the overall progress of science and technology in the world. As well as Unesco's own resources and those of the United Nations Development Programme (UNDP), resources of other United Nations bodies, funds-in-trust, and bilateral funds should be made increasingly available, in co-ordinated ways, to countries needing assistance in creating or strengthening institutions for training engineers and technicians. To support these institution-building activities, Unesco should give high priority to the encouragement and support of innovatory approaches to training manpower to meet local development needs in developing countries, including curricula design and the establishment of regional networks of co-operating institutions.

3. The Conference recommends to the Director-General that he continue to encourage and assist Member States, especially the developing countries, to create in their educational systems a broad base for technology, and to particularly ensure that the tools of technology are used not only in the modern sectors of the economy but are also available to modernize traditional productive activities, especially in rural areas.

4. The Conference also recommends that Unesco promote the adequate exposure to technology components of all secondary school students, especially in developing countries, so as to reduce the technological illiteracy of all students.

5. The Conference recommends that Unesco develop a strong international programme in collaboration with the International Labour Organisation (ILO), to assist Member States to strengthen all aspects of engineering technician training. This should form an integral part of the current long-term programme in engineering education but where appropriate there should be specific activities for technician training, including regional seminars and workshops, creation of training facilities for technician training staff on a national or regional basis, promotion of the status of technicians and technician teacher careers, and assistance to Member States in the education and training of technicians. In particular, Member States should also be encouraged to give higher recognition to technicians, commensurate with the contribution that they can make to national economic and social development.

6. The Conference recommends that Unesco, in its activities related to curricula, education-industry co-operation, and the environmental aspects of engineering education, should stress the importance of relating education and training more directly to the cultural, social, economic and natural environment. In particular, centres for studies and research on these priority areas of engineering education should be supported, and the results of their studies and research should be disseminated to all Member States.

7. The Conference endorses Unesco's policy of promoting world-wide reform of engineering education to reflect social and environmental needs. In particular, it notes with approval the support the United Nations Environmental Programme (UNEP) is giving to a global programme for the environmental education and training of engineers, and emphasizes the early effects which can be expected from these initiatives in engineering education. The Conference expresses its concern that the environmental education and training of engineers should receive high priorities in multilateral and national funding, and requests the Director-General to communicate this concern to the relevant authorities.

8. Bearing in mind that if Member States are to increase their capabilities to train engineers and technicians for their development needs, the actual rôles that such personnel need to play in their economies must be clearly defined, the Conference recommends that Unesco should foster the execution of manpower studies in its Member States and the exchange of information in this field, in close co-operation with other interested organizations. As part of this action, Member States should be encouraged to ensure that women have adequate opportunities to make careers as engineers and technicians.

9. With progress in science and technology occurring at an accelerating rate, in societies where needs and values are also rapidly changing, the problem of obsolescence of skills and attitudes of engineers and technicians has assumed major importance such that life-long learning and re-adaptation must be an integral part of their careers. The Conference therefore recommends that the Unesco activities in the continuing education of engineers and technicians be pursued and expanded, especially its capability to advise Member States on setting up new systems for this purpose.

10. The Conference expresses its strong conviction that close collaboration between education and industry is essential to good engineering and technician education, and recommends that Unesco encourage such collaboration at national and international scales. There must be a flow of information on training and research between universities and industry, and on practice from industry to universities. Engineers from industry should serve as visiting professors, and teachers in educational institutions should take periodic industrial residences either in their own country or one offering wider opportunities for industrial experience.

11. The Conference recommends that Unesco assist Member States in further developing the teaching competency of staff of engineering, technological and technician educational and training institutions through the development of regional engineering and technician teacher training courses on educational technology and by assisting related national teacher training programmes.

12. The Conference recommends that Unesco should consider holding a major international conference within the next six years to review progress in the implementation of these recommendations, especially those concerned with the training of engineering technicians. This should be at intergovernmental level, so as to offer the opportunity of reaffirming and institutionalizing the priorities and actions necessary for the further development of technological education in Member States.

B. RECOMMENDATIONS OF THE COMMISSIONS FOR AGENDA ITEMS 4(a) - 4(g)

At its final plenary session on 26 April 1976, the Conference adopted the conclusions and recommendations of the seven commissions that considered agenda items 4(a) - 4(g), as follows:

Agenda item 4(a): The quantitative and qualitative estimation of engineering manpower required for national socio-economic development, and the identification of levels and specializations. Women in engineering

Conclusions

1. The Commission calls the attention of the Director-General to the importance of the issue of engineering and technical manpower surveys and forecasts methods and its relevance to the Unesco mandate; being convinced that early action is urgently needed on this issue at the international, national and regional levels along the lines identified below.

2. The Commission recognizes the usefulness of the various approaches for forecasting manpower requirements as described, in a precise though brief form, in the position paper prepared by the Secretariat; yet, in spite of the inherent limitations of all known methods, which makes it imperative to use them with care, believes that such exercises are vital for an appreciation of education and training issues, not only those that are now apparent but also those as yet to arise. The Commission feels that a systems approach to manpower planning, with a sensitivity to the issues influencing demand at enterprise, national or regional level, would ensure more meaningful results.

3. The imbalance, apparent or real, between demand and supply of engineering personnel can best be resolved through flexibility in the educational and training system, and also in the wise utilization of continuing education policies and practices. It is also felt that to provide society with the required technical and engineering skills, it is necessary to use an integrated approach involving economic planners, educationalists, employers and employees organizations, as well as other professional groups.

4. The lack of technicians was underlined by a number of participants, who stressed also the need to adjust salary scales and working conditions so as to reflect the importance of the rôle of technicians in the economy.

5. It was agreed necessary to overcome the last barriers in the way of women's participation in engineering and technical occupations, within the context of prevailing social and cultural conditions and the particular needs of each country.

Recommendations

The Commission requests the Director-General to:

1. Facilitate the sharing of the experiences gained regarding the use and development of methods for forecasting engineering manpower requirements, both in quality and quantity. As the resolution of this problem is influenced by the differing national administrative structures in various countries, communication and feedback links are essential between those responsible for economic planning, education and industrial development.

2. Facilitate interchange of information on the results of such studies, as a means of improving their quality and their application by those responsible for education and training.

3. Foster continued activity by national groups dedicated to the study of the knowledge and skills actually used by engineering and technical manpower in the performance of their duties, and their comparison with educational curricula. In Member States where no machinery for such studies exists, it would be desirable to take appropriate steps to encourage governments to set up such groups.

4. Promote co-ordinated studies in specific sectors of common interest to a number of countries, which would provide insights into the social, techno-economic and other parameters that influence requirements for engineering and technical manpower.

5. Undertake the preparation of a reference document whose purpose will be to facilitate communication between countries based on the analysis of information from Member States on engineering and technical manpower, covering the titles and grades, the corresponding education and training content, and the task profiles of such manpower.

6. Set up an international working group for the purpose of communicating with national groups, facilitating the sharing of experiences, providing professional expertise, and functioning as an information clearing house.

7. Promote technician education in order to meet the acute shortages of technicians identified in many countries; and study ways of remedying these shortages, including concerted and international efforts in the field of technician education.

Agenda item 4(b): Curricula design, including teaching and learning processes, generalized curricula design, educational technology, rôle of research and project work, and evaluation

Recommendations

The Commission makes the following recommendations to the Director-General:

1. The methodological approach to curricula design presented by the Unesco international working group in Conference document TECHED/MISC. 2 is endorsed, and the Commission recommends that the development of this methodology should continue and be extended to include points of information and emphasis raised during the discussion.

2. The Commission recognizes the importance of the relationship between curricula design and teaching and learning methods and recommends that studies and research in this field should continue to be supported by Unesco.

3. Recognizing the importance of practical industrial experience to the education and training of engineers and technicians, this Commission recommends that opportunities should be provided for obtaining that experience. In those countries where industries are either very few or non-existent, educational institutions should be encouraged to establish centres for work experience to provide as wide a range of experience as possible.

4. The Commission recommends that any proposed methodology for the design of engineering curricula should be accompanied by descriptive and illustrative material covering various aspects of the design process in order to assist all those involved in curriculum design. This should include case histories, data on existing courses and check lists of factors and constraints which must be considered in terms of the course content and philosophy, the inclusion of industrial experience, methods of evaluation and the generation of interdisciplinary courses.

5. Considering the fact that the developing countries have to depend more on the quality of their technicians for rapid economic and industrial development in a manner suited to their particular needs, the Commission resolves that the place of the technician in society should be made higher than that now prevailing in many parts of the world.

6. This Commission believes that a systematic method offers the best approach to the design of curricula for the education and training of all levels of engineering technicians and recommends that any methodology used for this purpose should pay particular attention to the true needs of the local situation in terms of the number and nature of technicians required, to the statement of clear and unambiguous objectives, to the importance of integrating the educational and industrial elements of the curricula, and to the problems involved in providing vertical and lateral mobility for the students.

7. The Commission recommends that Unesco should take steps to stimulate at national and international levels research activities on problems in engineering and technician education.

8. The Commission reaffirms the view that because of the rapidly and radically changing social, economic, educational and technological factors throughout the world, it is necessary continually to revise and review engineering curricula. The Commission emphatically recommends that positive efforts should be made to reproduce and disseminate information on all aspects of curricula design, and that consideration be given to setting up of special centres and networks for this purpose.

Agenda item 4(c): Social and environmental considerations in the education and training of engineers and technicians

Conclusions and recommendations

The Commission agrees that the following points are fundamental:

1. That in the education and training of engineers and technicians there is a need to develop in students, teachers and practitioners not only knowledge and skills but also attitudes and awareness of social and environmental effects of technology, especially effects on the biosphere and the built environment.

2. That these attitudes and awareness should be developed in full recognition of all aspects of cultural and national heritage.

3. That the development of these attitudes and awareness requires an active learning process, training the students in decision-making by using informal learning material, for example, case studies, simulations and project resources.

4. That there is a critical shortage of such informal learning material.

5. Concerning academic structures, the Commission concludes that the generally preferable arrangement is one in which teachers in social and natural sciences and humanities are integrated members of engineering schools. In such situations, care must be taken to ensure that such teachers have job satisfaction and career opportunities equivalent to those of the engineering staff.

6. Emphasizes, however, that the primary rôle model for the engineering student is the engineering teacher. The central involvement of a "broad" engineer is the essential prerequisite in the development of more sensitive and aware engineering students. Such engineers can usefully be drawn from engineering practice, as well as from within the engineering school.

7. Concludes that both engineering and non-engineering teachers must expect their status to depend on their ability to bring insight and knowledge to the solution of real-life social and environmental problems. This conclusion in turn leads to the need for teacher training and retraining, and for arrangements within and between institutions and industry to bring it about. Such arrangements should be incorporated in the development of the networks referred to below.

8. Concerning the rôle of professional bodies, the Commission concludes that the professional bodies in engineering, under pressures of public opinion, are likely to encourage the development of effective social and other environmental components at all levels of technological education. The professional bodies are seen as providing an important link between employers, government and educational institutions, and as mechanisms for bringing educators together and for undertaking the re-education of practising engineers.

The Commission recommends to the Director-General that he:

1. Facilitate the development of regional networks in which educational and training institutions can prepare and disseminate informal learning material in this area.

2. Sponsor workshops for the preparation of such material and short courses to develop teaching skills in their use and, since specific institutions know their own strength and problems best, they should be directly involved with Unesco in the planning of the networks and workshops and in dissemination.

3. Commission brief reports on the progress of engineering schools which are making an integrated and trans-disciplinary approach to environmental education.

4. Promote the establishment of more effective links with professional bodies, particularly with regional bodies in engineering, with a view to ensuring that developments in environmental education are more responsive to local needs and aspirations.

5. Bring these conclusions and recommendations directly to the attention of Member States and regional bodies, urging them to implement them at all levels of education. Particular emphasis should be placed on re-education needs.

Agenda item 4(d): Continuing education in engineering fields, including objectives, mechanisms, and relationships with initial education and with employment

Recommendations

The Commission recommends to the Director-General that:

1. Unesco should request each of its Member States to identify one or more organization within it that could be given the responsibility of collecting and disseminating information about continuing education activities for engineers and technicians, and could be used as a channel for regional and international co-operation in this regard.

2. Unesco should encourage Member States to create and expand facilities for the continuing education of engineers and technicians, located both in industry and educational institutions. This may include the establishment, with Unesco help if appropriate, of fully equipped centres of continuing education to which access would be available to individuals, groups of individuals, and organizations to meet their specific needs.

3. Unesco should bring to the notice of all Member States the French law of 16 July 1971 and recommend that fiscal and statutory incentives be given to industry to encourage participation of their employees in programmes of continuing education, so ensuring higher productivity, better utilization of manpower, and the fulfilment of the individual.

4. Unesco should sponsor at national and regional levels studies to determine the cost-effectiveness of various educational technologies used in the continuing education of engineers and technicians. The results of such studies should be widely disseminated by Unesco.

5. Adequate recognition be given in all countries to the important rôle of higher technicians in national development. Opportunities should be given to them for professional development both through specially-structured formal initial training programmes and through continuing education programmes. The salary and status of engineers and technicians should be commensurate with the professional competence and contribution of the individual rather than being fixed to his formal educational qualifications.

6. Unesco should encourage Member States to give special attention to the continuing education needs of the teaching staff of engineering educational institutions, through programmes of study leave, participation in short- and long-term continuing education activities, and experience in industry.

7. Unesco and other concerned organizations should establish a system for the mutual exchange of technicians and engineers for continuing education in universities or industry between various countries on a co-operative basis. A list of countries and industrial organizations wishing to participate in an exchange programme of this nature should be drawn up by Unesco.

Agenda item 4(e): Education-industry interaction in technological education, in industrialized and developing countries

Conclusion

The Commission unanimously concluded that the process of education and training of engineers and technicians is a prolonged process and one in which both educational institutions and employers must participate. In many instances, however, this educational process suffers because the links between these two groups are inadequate. If communication between education and industry can be improved, there can be greater understanding of their complementary rôles and a greater degree of co-operation in making the education of engineers and technicians more relevant and effective. Furthermore, this will also ensure that research activities will make a better contribution to the training process and to national development needs.

The Commission agreed that while the basic problems to be overcome were the same in most countries, the local needs varied and the mechanisms for facilitating co-operation needed to be chosen in the light of the local social and economic situations.

Recommendations

The Commission recommends to the Director-General that projects and activities in teaching, research and engineering practice should be carried out jointly by educational institutions, professional bodies and industry, and, in particular, that:

1. There should be joint industry-institution committees on curricula at all educational institutions for engineers and technicians. This should always involve initial and periodic studies of the needs of industry, to ensure that the curricula then drawn up will be relevant to the local situation.

2. Consultancy centres and production units should be established within educational institutions, so as to provide opportunities for faculty members to tackle real life problems and acquire practical experience. They also provide opportunities for better planned practical training programmes for students, and may also enable specifically local problems concerned with, for instance, rural development or training of local entrepreneurs, to be tackled.

3. Industrial experience should be a necessary part of the requirements for continued employment and advancement of academic staff. This should be seen in contrast to existing practices of judging academic staff merely from research publications. To help to achieve this, academic staff who do not have sufficient industrial experience should be encouraged to spend sabbatical leaves in industry. This naturally implies that institutions must develop means of assessing effective industrial experience, comparable to the present means for assessing research publications.

4. On the other hand, educational institutions, in co-operation with industries and professional bodies, should organize refresher courses for engineers and technicians from industry, tailored to update their knowledge and give them new insights.

5. Audio-visual aids and case studies prepared jointly by industry and institutions, reflecting local situations and problems, should be used in teaching. Furthermore, reports on development projects should be freely available to institutions, so as to help to improve the quality and local relevance of teaching.

6. To improve practical training of students and recent graduates, staff colleges for training the training officers in industry and educational institutions should be established.

7. In arranging all future international, regional and local meetings convened to discuss education-industry co-operation, special efforts should be made to ensure that more personnel from industry participate, so as to throw more light on the problems.

8. Unesco should carry out a series of studies on the difficulties associated with institution-industry interactions and should also disseminate information on the means by which such difficulties have been overcome in various countries. Such studies should also include examples of any legal and fiscal measures by which co-operation has been facilitated in Member States.

Agenda item (f): Institution-building in technological education, including educational systems, management, and physical facilities; staff development policies and problems. Student selection, guidance and motivation

The Commission focused its attention on staffing, educational systems and the management of institutions, physical facilities, and students. It brings the following conclusions and recommendations to the notice of the Director-General:

The Commission concludes:

1. Teaching staff for engineers and technicians do not have, in general, an adequate amount of practical experience. The reward system in the academic world does not recognize sufficiently contributions to the practice of engineering.

2. Engineering teaching staff do not have adequate formal exposure to the body of knowledge concerning teaching and learning methods.

3. Salaries of engineering teachers, especially in less industrialized countries, are not always compatible with their experience and ability and thus are not competitive with those paid in industry.

4. Engineering schools often do not have adequate plans for their institutional development and for the careers of individual members of the staff. Such plans as exist often fail in their implementation because of other aspects of institutional policies.

5. The divisions that appear to invariably exist between engineering faculties and faculties in such fields as sociology, economics, commerce, and the humanities must be broken down, as it is interdisciplinary activity between these groups which is of most relevance to modern society.

6. Continuing education and other programmes given in educational institutions for practising engineers and technicians from industry should be in general interdisciplinary in character and should relate to the real problems of local industry or national development.

7. At a national level, continuing studies should be made of the costs of all forms of education and training of engineers and technicians, as information now available indicates wide variations in cost per student between institutions, not necessarily corresponding to differences in the competence of the graduates. The rôle of industry in helping to reduce costs by paying for research or production work done in educational institutions should also be considered. Educational institutions should also examine their own cost effectiveness, so as to develop new knowledge about real costs and thus the real use of funds.

8. Because the overall benefits to society of the education of engineers and technicians are rarely reflected in traditional methods of educational costs analysis, Member States should be made aware of the value to their integrated development of investments in technological education.

9. Home-made laboratory equipment can often be much cheaper and sometimes more instructionally effective than commercially available equipment. There is a need for a mechanism to disseminate information on building such apparatus. Journals of engineering education should be encouraged to fill this need.

10. Engineering schools need adequately trained craftsmen and technicians for the maintenance and construction of equipment for laboratories, classrooms, libraries, and workshops. Such people are a prerequisite in establishing institutions and therefore should be recruited and trained as soon as the institution is created.

11. Expensive commercial equipment located in industry has been used in some cases for student training, a suitable contractual arrangement being drawn up between the institution and the enterprise. The Commission suggests that this type of co-operation be more utilized, obviating the purchase and subsequent under-use of equipment in institution laboratories.

12. In one Member State technical equipment centres containing equipment and instructors have been set up, each serving a number of technical schools. The Commission notes this as a very good way of fully utilizing teaching equipment.

The Commission requests the Director-General that he note and take appropriate action on the following specific recommendations:

1. Engineering schools must have adequate planning for individual and institutional development. Such plans need to be continuously revised.

2. Engineering teaching staff should have engineering experience of local relevance and this should be a continuously renewed process throughout their careers.

3. Higher education bodies should recognize the value of appropriate industrial experience, when considering salary and promotion of teachers of engineers and technicians.

4. Because the acquisition of a significant and continuing industrial experience by teachers represents a departure from present practice, Unesco should study methods whereby education and industrial organizations can co-operate to make such procedure feasible.

5. Engineering teaching staff should have the opportunity of becoming aware of modern teaching and learning methods.

6. Unesco should initiate studies and action that would lead to an eventual reduction in the cost of engineering textbooks, which in many countries is now very high.

7. Unesco should take the lead in providing regional courses in pedagogy for teachers of engineering and technicians.

8. Engineering teaching staff should be offered salaries and working environments competitive to those of industry.

9. To produce teaching staff whose backgrounds are more relevant to the needs of developing countries and also to overcome the problems of brain drain, it is recommended strongly, firstly, that the prestige and integrity of the technicians be considerably enhanced and, secondly, that selected post-graduate courses should be promoted in the developing countries. Because material and human resources are scarce, when appropriate these post-graduate programmes should be carried out on a co-operative regional basis.

10. To assist in overcoming the problems of brain drain, Unesco should undertake a programme leading to a recommendation which would assist developing countries in the repatriation of their young people who have studied abroad.

11. Unesco should review educational experiments on new programmes of study in engineering and technical institutions and disseminate the findings to all institutions in Member States. This should include new areas of specialization and programmes linking several traditional areas.

12. Unesco should formulate practical guidelines on how institutions can undertake cost-benefit analysis to assist Member States in their planning and decision-making.

13. Unesco should organize regional seminars or study tours on the management of engineering and technical institutions in order to increase the effectiveness of the leaders of these institutions.

14. Unesco should arrange, on request, short-term consultancies for skilled technicians to go to less developed countries to give intensive courses on the maintenance of electronic apparatus and scientific instruments.

15. Unesco should continue to develop basic design requirements for laboratories and for equipping them adequately, emphasizing the advantages of sharing expensive equipment between neighbouring institutions. The specifications of laboratories should include requirements for space, services, workshops, floor loadings, etc.

16. Unesco should assist Member States to develop basic requirements for libraries and information centres in engineering and technical institutions.

17. Unesco should assist Member States to set up national instrument centres for the fabrication, assembly, maintenance, repair and calibration of scientific instruments and certain types of apparatus.

Agenda item 4(g): Co-operation in technological education at international, regional and country levels

The Commission recommends to the Director-General that:

1. Unesco continue and expand its long-term international programme in engineering education, by stimulating work in priority areas and by promoting mechanizing for international and regional co-operation, especially by assisting regional associations and sub-regional groups to further develop their co-operative activities.

2. Unesco develop a strong international programme to assist Member States to strengthen all aspects of technician training. This should form an integral part of the current long-term programme in engineering education but where appropriate there should be specific activities for technician training, including regional seminars and workshops, promotion of training facilities for teaching staff on a national or regional basis, promotion of the status of technicians and technician teacher careers, and assistance to Member States in the education and training of technicians.

3. Unesco should continue to support bilateral, multilateral, regional and international action-oriented programmes in the area of engineering and technician education and training, including continuing education. In particular, Unesco should sponsor, on request, meetings taking place in Member States and convened by national, regional and international bodies, where such Unesco sponsorship will enhance the success and international co-operative nature of the meeting.

4. Unesco should encourage Member States to create or strengthen national associations concerned with education and training of engineers and technicians so that their engineering communities are better able to benefit from regional and international co-operative activities.

5. That the Unesco programme of promoting regional associations for engineering and technician education be continued and expanded and that stronger links between these associations and other international or national organizations be encouraged. The collaboration between Unesco and the World Federation of Engineering Organizations (WFEO) should also be strengthened.

6. That as a long-term measure Unesco promote the strengthening of the Union of the International Engineering Organization (UATI) so that it will be able to play a rôle for the engineering sciences comparable to that now played by ICSU in basic scientific fields.

7. Unesco should continue to assist Member States, especially the least developed countries, in the establishment and strengthening of institutions for the training of engineers and technicians using the resources of the United Nations Development Programme (UNDP), the United Nations Environmental Programme (UNEP), funds-in-trust, other extra-budgetary funds, or its own resources. A particular effort should be made to strengthen facilities for post-graduate education, research, and development in developing countries, so as to reduce the need for prolonged study in the developed countries. This should include the formation of networks of co-operating institutions with a common dedication to concentrate on problems of regional relevance. Inter-institutional links should also be promoted, for technical training institutions as well as for engineering schools.

8. Unesco should strengthen its own activities in the collection and dissemination of information on engineering and technician education, and encourage Member States to do likewise by establishing or strengthening national information facilities, for example on new teaching methods, laboratory equipment lists, management of institutions, and reports on innovatory methods for training manpower able to adapt technologies to meet the needs of developing countries. In particular, Unesco should promote international sharing of teaching material for training technicians, especially that able to be adapted for use with local languages. That international information systems such as UNISIST (Unesco), IRS (UNEP), and OPI (UN), should be encouraged to encompass information on the education and training of engineers and technicians.

9. Unesco should facilitate the international exchange of engineering and technician teaching staff by such means as studies on the equivalence of diplomas, programmes enabling teachers to obtain industrial experience in other developing or industrialized countries, measures to facilitate the re-adaptation in developing countries of national teaching staff after prolonged residence abroad, encouragement of teachers from industrialized countries to spend periods of teaching and research in developing countries, and assistance to its Member States in identifying and recruiting teaching staff.

10. Unesco encourage world-wide communication between those concerned with technological education, through its own means and those of the appropriate professional engineering bodies, learned societies and societies for engineering education. To facilitate such communication, the compilation of glossaries of terms and acronyms used in discussion on technological education should be supported, as well as lists of associations involved with technological education.

11. That Unesco should consider holding a major international conference within the next six years to review progress in the implementation of the recommendations of this meeting, especially those concerned with the training of engineering technicians. This could be at intergovernmental level, so as to offer the opportunity of reaffirming and institutionalizing certain major recommendations to Member States.

ANNEX I

AGENDA

1. Opening of the Conference by the Director-General or his representative, and by the representative of the Government of India.

2. Election of the President, Vice-Presidents and Rapporteur-General.

3. Main trends in technological education since 1968, current challenges, and perspectives in industrialized and developing countries.

4. (a) The quantitative and qualitative estimation of engineering manpower required for national socio-economic development, and the identification of levels and specializations. Women in engineering;

   (b) Curricula design, including teaching and learning processes, generalized curricula design, educational technology, rôle of research and project work, and evaluation;

   (c) Social and environmental considerations in the education and training of engineers and technicians;

   (d) Continuing education in engineering fields, including objectives, mechanisms, and relationships with initial education and with employment;

   (e) Education-industry interaction in technological education, in industrialized and developing countries;

   (f) Institution-building in technological education, including educational systems, management, and physical facilities; staff development policies and problems. Student selection, guidance and motivation;

   (g) Co-operation in technological education at international, regional and country levels.

5. Education and training in technological fields as a prerequisite for development. Discussion of possible strategies to be used in the next decade to ensure that education and training will better contribute to world-wide social and economic development.

6. Adoption of conclusions and of recommendations to the Director-General.

7. Closure of the Conference.

ANNEX II

OPENING ADDRESSES

ADDRESS BY MR. K.N. CHANNA, SECRETARY-GENERAL, INDIAN NATIONAL COMMISSION FOR CO-OPERATION WITH UNESCO AND SECRETARY TO THE GOVERNMENT OF INDIA

On behalf of the Indian National Commission for Co-operation with Unesco, the Government of India and myself, I have great pleasure in welcoming you all. I extend a special welcome to the participants and their wives from abroad. I should like to thank Unesco for accepting our invitation to hold the Conference in India. I am confident that the deliberations will be of immense help to all the member countries of Unesco for the proper development of their engineering education programmes.

It is gratifying indeed that, in your deliberations, special attention will be paid to the problems of developing countries in planning and development of technical education at all levels to train personnel required for economic development. It is also a matter of satisfaction that this Conference will devote special attention to the review of the programmes on international co-operation in engineering education and examine the overall status of international and regional co-operation in the field.

We, in India, starting almost from scratch, built up a large network of technical institutions to provide basic infrastructural facilities for the promotion of technological development, during the last quarter of a century. There has been a tremendous expansion and immense qualitative improvement in higher education, including technical education.

In this process, we have received considerable assistance in the form of experts, equipment and training facilities for our teachers abroad, from several countries under technical assistance programmes and through United Nations agencies. Under cultural exchange programmes with various countries, we encourage exchange of students and teachers for training and research. About 500 foreign students are provided training every year in our technical institutions in engineering colleges as well as in polytechnics. We have organized special training programmes for students from some friendly countries in our universities and polytechnics to meet the requirements of their own countries.

During this period, we gained experience and developed expertise in manpower planning, establishing new institutions or developing the existing institutions and in the qualitative improvement. This experience and expertise, we believe, will be relevant to a large extent to the developing countries.

I trust that, during the course of your deliberations in the next few days, you will have an opportunity to exchange and analyse your experiences. We are, therefore, grateful to Unesco for providing such a forum to all its member countries which is indeed a great service to the cause of engineering education and training.

Friends, I am conscious that you are anxious to hear Professor S. Nurul Hasan, President of the Indian National Commission and Union Minister for Education, Government of India, who has been an educationist of great eminence. We, in India, have been fortunate in having the benefit of the advice and guidance of an educationist of his stature and experience for the last five years. I should not, therefore, like to stand any longer between you and the chief guest and request him kindly to inaugurate the Conference.

INAUGURAL ADDRESS BY PROFESSOR S. NURUL HASAN, PRESIDENT OF THE INDIAN NATIONAL COMMISSION FOR CO-OPERATION WITH UNESCO AND THE MINISTER OF EDUCATION, SOCIAL WELFARE AND CULTURE, GOVERNMENT OF INDIA

I am deeply grateful to Unesco for having invited me to inaugurate this international Conference on the Education and Training of Engineers and Technicians. As a student of history, I have accepted the invitation in a spirit of humility. I join my friend and colleague Shri K. N. Channa in welcoming you all who have come from abroad as also those who have come from distant parts of India. To all of you specially our foreign guests our special thanks are due.

I believe that almost all the developing countries like India which have emerged from subjection into freedom are now attempting to raise the living standards of their people to fight poverty and hunger, disease and deprivation, illiteracy and backwardness and to enrich the quality of life of their citizens. Unfortunately this cannot be done while there exists a system in which the bulk of the resources of the earth are appropriated by a handful of individuals and countries. The struggle for development is, therefore, a common struggle of all humanity to ensure a just international order. The United Nations is now deeply concerned with the achievement of this objective. The non-aligned countries, the developing countries, the Afro-Asian and Latin-American countries have jointly given a call for the realization of these goals. International peace and co-operation is dependent upon the capacity of the world to ensure an equitable distribution of whatever resources the earth has to offer. The future of humanity is also dependent upon the preservation of man's environment, based on deep study and understanding. Above all, we must ensure that nuclear power is utilized for the good of man. It is in this context that science and technology have to play a very important rôle. Modern science and technology can be used for two contradictory purposes - to perpetuate the unjust social order existing today with the danger of universal destruction, or to build a new and just world order. A conscious choice has to be made about the direction in which science and technology have to be taken. I hope that it will play a decisive rôle in economic planning and development and in increasing agricultural and industrial productivity, specially for the benefit of the deprived sections of humanity. Soon after our freedom Jawaharlal Nehru visualized the crucial rôle of science and technology in human development not only in the context of material development but also for changing the outlook and way of life of the people.

His penetrating vision of the multifaceted rôle of science has provided the guideline for India's policy of development and progress. The Scientific Policy Resolution adopted by the Government in 1958, states in clear terms that it is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of a recognition of this possibility that the idea of a welfare State has grown. The Resolution goes on to say that the wealth and prosperity of a nation depend on the effective utilization of its human and material resources through industrialization.

Under the leadership of Jawaharlal Nehru, we tried in this country to build up an infrastructure of science and technology. We have gradually been able to establish a large number of institutions of scientific research, of technical education as well as technician education. We have also tried to ensure that our system provides for vertical mobility, so that the skilled worker can be transformed into a fully-trained engineer. We are willing to share our facilities with our neighbours in the true spirit of internationalism. Those who have similarly suffered are entitled to a share of whatever may be our modest achievement. But I would like to submit that in the name of sharing of human resources we should not allow a situation to develop in which the meagre resources which are utilized for building up the infrastructure of science and technology are frittered away in a reverse flow of aid from the developing to the developed countries in the form of "brain drain". We must therefore apply our mind to the type of education which we must impart so that our scientific and technical personnel emerge as individuals committed to the task of finding solutions for the problems facing the bulk of the common people in the developing countries. We must also ensure a flexibility of approach so that the absorption

of the latest techniques and innovations becomes a process simultaneous with that of the translation of new ideas and concepts into methodologies suited to the solution of native problems.

All countries, especially those of the developing world, will have to choose the type of technology that they find most suitable and appropriate for their needs. No country, I would respectfully submit, can prescribe what is the specific mix of technology which is best suited to the development and advancement of any other nation. I am aware of the trend of thought in certain developed countries that all the sophisticated research should be left to either the developed world or their multinational corporations and that the only responsibility of the developing nations is to provide for adaptive research so that the results can be made available cheaply. If poverty could have been removed by primitive technology, most countries of the world would not have remained underdeveloped today. Nor has the accelerated development of technology in a few countries, solved the problems of backwardness of the many. This does not mean that the developing countries can afford the luxury of being imitative. While we must develop our capacity for the most sophisticated research effort, we should simultaneously think of simple solutions to simple problems which can be repeated and multiplied for the benefit of millions of our people so that their suffering and poverty are alleviated.

This country, like most of the other developing nations, is predominantly agricultural. It is obvious, therefore, that science and technology must not only be utilized for building the industrial infrastructure so essential for any kind of development, but also for solving the day-to-day problems of the countryside including the chores facing the housewives in villages. Undoubtedly, an intellectual effort of the highest order is required. At the same time this intellectual effort has to be accompanied by an understanding of the processes of society, so that technology and science are not developed in a vacuum, but are related to the resources, human as well as natural, which are available. What is demanded is a system of values based on humanism. It must be remembered that science provides a means for achieving certain ends and that an understanding of these ends is as essential as the understanding of the means. I would, therefore, submit for your consideration that in designing courses and curricula due care should be taken to see that the old concept of two cultures is effectively ended, that science and technology on the one hand, and social sciences and humanities on the other, are given adequate opportunities to interact with each other. It is only under such a system that a graduate of technology will be in a position to play a balanced, integrated rôle and fulfil his social responsibility.

It must also be borne in mind that knowledge can never grow without its application. Concepts in the abstract have but limited relevance unless verified by the test of practicality. Removed from reality, neither the concepts nor the mind absorbing them is capable of healthy evolution. It is therefore necessary that the results of our most sophisticated scientific and technological research are utilized by industry and agriculture. To make the circle complete the methodology of teaching must be aimed at training the minds of our young students to find solutions for concrete problems, so that there is no divorce between theory and practice.

The modern scientific and technological era has rendered the concept of absolute knowledge totally obsolete. It is widely agreed that education must pay increasing attention to mastering methods of acquiring knowledge rather than merely distributing and storing it. The explosion of knowledge has resulted not only in the amazing expansion of data and facts but also in the rapid obsolescence of this knowledge. Faced with these new imperatives, it is obvious that education, in the broadest spectrum of the term, must be made accessible through different paths and in many forms so that there is ample scope for continuing self-improvement and development. There must be freedom of choice both as to the means and the methods, whether it be full-time education, part-time education, self-education or education by correspondence. All these must be regarded as equally valid and interchangeable at the learners' will. The accent should always be on the final result. The basic problem facing education has been effectively summarized in the words of the Prime Minister of India, Mrs. Indira Gandhi:

> "Education is not so much what one learns but what type of person it helps one to become. It is not the accumulation of knowledge but the ability to use it with perception and compassion. It is a constant striving to stretch one's awareness and one's capacity to learn to feel and to be. This is indeed a high aim and we are nowhere near it."

If the young men and women of today are to be enabled to make their full contribution in the rapidly changing world, it is essential that the idea of continuing education be formulated in close co-operation among the technical institutions, industry and the universities. Whatever be the methodology, the objectives of such education, especially in the field of technical education, should be clear to all. It must be ensured that the personnel already employed are given

opportunities to better their qualifications and improve their positions via a system of horizontal and vertical mobility. Attention must also be paid to improving job performance and guarding against the danger of technological obsolescence.

While it is true that reorganization in the educational system must be brought about as soon as possible by the introduction of new curricula and meaningful innovations, it must not be forgotten that the teacher remains the single, most important instrument of change. Unless he is adequately trained and committed to his task of fashioning young minds capable of transforming societies and social relationships, the best efforts to introduce vigour in the system itself would be of no avail. The methods of training and retraining teachers on a continuing basis, the means to equip them with the up-to-date experience of the processes of production, the inculcation among them of a sense of identification with the working class and its aspirations, the opportunities that must be created for them to develop their areas of knowledge are all matters of utmost concern and must be given the most serious consideration.

All the countries of the world whether developed or developing, rich or poor, are realizing more and more not only the urgencies of their own national objectives but the need for the pooling together of the international resources of mankind for the solution of global problems. Whether it is in the field of industrial or economic development, the eradication of poverty, disease and backwardness or overhauling education, nations and societies have to learn to co-operate with each other and share their experiences. The exchange of educational experience is undoubtedly one of the most important forms of such co-operation. Dissemination of information on educational innovations, exchanging teachers and students bringing about closer links among the various institutions attempting to correlate curricula and educational methods as they exist in various parts of the world are fundamental to this concept.

Friends, knowledge and skills are intended not merely to satisfy the eternal quest of the human soul but also to generate, guide and support the efforts needed to promote the welfare of the people which is both their objective and obligation. From this point of view, therefore, I attach the highest significance to the pursuit of equality as a basic human value and to man's ceaseless efforts in spite of all odds to provide equality of educational, economic, political and social opportunity irrespective of caste, creed, race, colour, religion or sex. It is a truism to say that men are unequally endowed and start unequally in life. We also realize that they strive unequally and tend to finish unequally at the end. We do recognize that there are tremendous prejudices and vested interests in favour of the creation and perpetuation of inequalities and temptations to rationalize by saying that some are more equal than others. And yet we insist upon equality before the law. We assure each person that he has equal protection and that he will be judged by the same criteria and treated the same way for his actions as every one else. We also insist on social equality and assure each person that he will be given the same basic respect as an individual along with all others. We also assure every individual an equal right to participate in production, in programmes of national developments, or in the governance of society. We also hold that every individual has an equal right to the minimum of income and services like education, medical care or social security. I consider the struggle for equality as the best attribute of human civilization and to me, technology - in fact all knowledge - is valuable and useful only in so far as it tends to promote equality and to improve the quality of life of human beings all over the world.

I am grateful to you for having given this patient hearing and the opportunity to share my thoughts with you. I have great pleasure in inaugurating this Conference.

ADDRESS BY THE REPRESENTATIVE OF
THE DIRECTOR-GENERAL OF UNESCO

Honourable Nurul Hasan, Minister of Education and Social Welfare,
Dr. Ramachandran, Secretary to the Government of India at the Department of Science and Technology,
Mr. Channa, Secretary-General of the Indian National Commission for Unesco,
Distinguished participants and observers,
Ladies and gentlemen,

Speaking on behalf of the Director-General of Unesco, Mr. Amadou-Mahtar M'Bow, I would like to recall that eight years ago, on 8 December 1968, the International Conference on the Trends in the Teaching and Training of Engineers was opened in Paris by the late Mr. René Maheu, then Director-General. It was the first meeting of its kind and the predecessor of our present Conference. The General Conference of Unesco, at its eighteenth session held in Paris at the end of 1974, authorized the Director-General to convene in 1976 an International Conference "on the development and improvement of the education of engineers, technologists, and higher technicians". After more than one year of preparatory work, it is indeed rewarding for the Organization to recognize the presence here today of such a distinguished and representative group of technological educators of practising engineers and other technologists, manpower planners, economists and social scientists, which testifies the importance that is placed throughout the world on technological manpower development and on the possibilities provided by international co-operation and exchange of experience in this field.

Unesco's profound gratitude is due to the generous invitation and hospitality of the Government and people of India for this opportunity of meeting in New Delhi, and particularly to his Excellency, Professor Nurul Hasan, Minister of Education and Social Welfare, for honouring us with his presence and inaugurating the Conference. I would also like to pay tribute to the precious contribution that has been made by the local organizing committee in preparing for the work that you are starting today. This event has amongst its objectives the special consideration of development problems as they relate to the education and training of engineers, and so I see fitting - and I am sure you agree - that we should meet in a country such as India, rather than in our Headquarters in Paris.

We are here to review the changes that have taken place since 1968, and it is clear that there are many. Science and technology have evolved at a rapid rate, and the qualitative and quantitative demands for engineering personnel have shifted in many countries. Many of the developing nations continue to face severe shortages of the professionals and technicians that they need for their development plans, and in the advanced countries we have often seen shortages or surpluses of highly-trained personnel.

We all know that during recent years engineering and technician education have also been changing in their approach and content, but many will argue that change should have a more systematic and rational basis. This is, perhaps, the focus of our discussion at this Conference, how to systematically improve the quality and relevance of technological education.

There is also an ethical and social dimension of this problem of technological manpower. In September 1975, the General Assembly of the United Nations indicated its determination "to eliminate injustice and inequality which afflict most sections of humanity" and consciousness "that the accelerated development of developing countries would be a decisive element for the promotion of world peace and security". The resolution approved in this respect was based on the Declaration and the Programme of Action on the Establishment of the New International Economic Order, as well as the Charter of Economic Rights and Duties of the States, which laid down the foundations of this new order. The very existence of such Programme and Charter are in themselves a measure of the social and ethical preoccupation of our world of 1976.

There is no doubt in my mind - without losing sight of the peculiarities of the needs in particular countries and regions - that the education and training of engineers and technicians demands continuing reform and modernization in the developing countries and also in the industrialized ones, where such education and training started in its contemporary sense.

Perhaps the new concept that has emerged in developing countries is that through an effective utilization of their own talents such countries may be able to devise technological education systems that satisfy more fully and efficiently the needs of their own societies and economies. The importation of external models which may be obsolete by several decades in their fundamental conception, could constitute a form of building into the education infrastructure a still greater retard in terms of the process of development. We should not forget that coming late to industrialization gives developing countries the rare advantage of being able to avoid the mistakes of the technically more advanced ones.

In this regard the example of India is illuminating, especially the stress being given to the application of science and technology to rural development. At the Indian Science Congress session held in January of this year, Prime Minister Indira Gandhi referred to the fact that the overwhelming majority of the Indian people live in villages, and that solutions and expedients worked out in countries where the agricultural population form but a small part of the work force cannot serve India. She mentioned the need for greater attention to rural engineering, and the importance for universities and laboratories to come closer to the villages. I hope that in our discussions here at this Conference we will also face up to the problems of how to educate engineers and technicians so that they will be able to work effectively on rural development projects as well as modern industry, on adapting and creating technology to meet national needs.

But the problems do not concern only the Third World. The voices of engineering and technician educators in the industrialized countries are not without tones of anxiety. They urge that more account should be taken of the interaction of technology with society and with the environment.

Most educators agree that the engineers and technicians that we are preparing today must have a strong scientific background, so as to be capable of effectively serving their societies beyond the end of the century, and must have the ability to develop their technical knowledge to satisfy the increasingly complex needs of these societies. Therefore technological education planning becomes - like all planning - a process of social and technological forecasting. Viewed in this manner, it involves a delicate exercise of imagination and judgement in which science and technology and socio-humanistic insight are inseparable ingredients.

Ladies and Gentlemen,

As you know, the programme of Unesco covers the entire spectrum of education, in education planning, in literacy work, in educational research and development, and in education in scientific and technological fields. On one hand, Unesco strives to assist its Member States to solve the problems involved in the reform and improvement of their education systems, and on the other, helps them to develop mechanisms for regional and international co-operation. For technological fields we must view these systems as including the universities, institutes of technology, polytechnic institutes, specialized technical schools and the growing range of facilities for the in-service training of engineers and technicians.

Unesco has been actively involved in the establishment and strengthening of engineering and technician schools in some 50 Member States, under the United Nations Development Programme. Well over 60 institutions, with a combined enrolment of more than 200,000 students have benefited so far from these operational activities. These programmes are continuing, but with more emphasis on strengthening national systems of technological education and on improving endogenous research capabilities in engineering schools in developing countries.

Based on the recommendations of the 1968 Conference we have been carrying out a long-term programme, with the active participation of many of you, that has been designed to improve mechanisms for regional and international co-operation in engineering education. We have chosen priority fields such as curricula design, education-industry co-operation, and continuing education and have sponsored working groups, studies, regional exchange visits, seminars, and publications. Whenever possible we have tried to encourage and support comparable activities being carried out by other international, regional and national groups. One of your tasks here at this Conference is to take stock of what has been done under this programme, to advise the Director-General on what changes in priorities need to be made and what you consider as the most important spheres for our action in the coming year.

Some of the recent trends are clear, such that we have already begun to engage ourselves in these new directions. For instance, we have started studies on how to introduce more environmental and other social concerns into the education of engineers and technicians. Taking into account the growing interest in regional co-operation, we have begun to look into the possibility of creating regional co-operative networks of engineering schools, firstly in Africa. These are only two examples of possible new directions for our efforts, and I expect that during our discussions we will identify a number of others.

In the document SC/TECHED/4, the annotated agenda, you will find many of these problems described and many questions asked, and I hope that these will stimulate our discussion. In addition, there are a number of other subsidiary Conference documents that are not to be presented in any formal sense, but will provide us with background for our discussion in the working sessions of the Conference.

There are two major problems that need our consideration during this Conference. One concerns technicians - their education and training, their status, and the reasons for the extreme shortages of technicians in many countries. This is a complex matter, with many social and economic implications, and we would like your views on the steps that Unesco could take to assist its Member States on this problem. I might add that, for the slightly lower and more general level of technical and vocational education, Unesco and the International Labour Organisation (ILO) have recently revised an international recommendation to Member States, and this is amongst the documents that you will have.

The second major problem to which we are being asked to give special consideration is concerned with the efforts of the developing countries in training engineers and technicians appropriate to their needs. Many aspects are important. Some, such as the financing, building, and staffing of new institutions are of essentially practical nature. Others are conceptual, for example, the design of curricula, and decisions of what educational levels and specializations should be adopted.

Ladies and Gentlemen,

I do not wish to go further into the various questions which you are about to examine, but I would like to stress that the conclusions that you reach will be extremely valuable to the Director-General. He will submit to the General Conference, at its nineteenth session to be held in Nairobi in October this year, a report describing the outcome of this Conference. Thus any recommendations that you may wish to make to the Director-General concerning concerted action on an international or regional scale will be reviewed in a very favourable light. The clearer picture we have of your problems as you yourselves see them, the more readily will we be able to help you to resolve them. The financial resources of Unesco are very small in comparison with the needs, even taking into account funds from other United Nations sources, but our experience has shown that the Organization often is able to perform an effective catalytic rôle of its own.

At the international level, Unesco has the mandate to consider the development of technological manpower as means of facilitating the access of the poorer countries to the fruits of contemporary material progress, thus contributing to the disappearance of world social injustices. This in essence brings us to the fundamental task of the Organization which, as stated in its now thirty-year old Constitution, is no other than to "contribute to peace and security by promoting collaboration among nations through education, science and culture..."

It is in this international spirit and with this firm hope in my mind that I wish you the most fruitful and illuminating deliberations in this Conference.

ANNEX III

STATEMENT ON TECHNICAL EDUCATION FOR DEVELOPMENT DELIVERED AT THE FIRST PLENARY MEETING BY DR. A. RAMACHANDRAN, SECRETARY TO THE GOVERNMENT OF INDIA, DEPARTMENT OF SCIENCE AND TECHNOLOGY, CHAIRMAN OF THE INTERNATIONAL CONFERENCE ON THE EDUCATION AND TRAINING OF ENGINEERS AND TECHNICIANS

Ladies and Gentlemen,

The primary objective of developing countries is to achieve within a measurable period of time economic progress so as to improve the quality of life of the people in rural and urban areas. This implies the transformation from a traditional economy to an economy based on science and technology. A modern society cannot be sustained without trained personnel who are innovative and concerned with the socio-economic impact of the technologies. One of the important functions of technological institutions is to build up a reservoir of such intellectual capital, and engage itself in the creation, transmission and utilization of knowledge.

The world is entering into a new phase of mass education which necessitates the establishment of new types of universities and institutions, new disciplines and new courses, new kinds of learning facilities, new types of laboratories and libraries, new ideas of learning, new methods of teaching and last but by no means the least, new educational technology media for communication and evaluation. There is a common feeling not only in my country but in many other countries of the world, of the need for reappraising curricula and teaching methods used in engineering education. Our aim must, therefore, be to improve the performance of the educational system, to changes that will make them more relevant to the needs of the concerned country, more efficient in the use of available resources, both material and human and a more effective force for individual and national development. With rapid technological advances, the educational system will have to change more frequently and more rapidly than in the past. Instead of the usual ad hoc method of superimposing something new on top of the old, it would be better to consider an alternate approach, namely the methods of system design which has been successfully used in many other fields. A systems approach to educational design begins with a clear set of objectives, the constraints and environmental factors to be observed and devise a variety of possible systems that might be employed to achieve these specified results. In designing new teaching/learning methods in this manner to accomplish the desired objectives, the chances are that an optimum system will emerge which might be a combination of some old and new fitted together in a logical manner rather than on the basis of ad hoc adjustments and creating frustration among all concerned.

The institutional framework for technical education in India is provided by the institutes of technology, 141 engineering colleges at the degree level and 291 polytechnics for technician training leading to the award of a diploma. In addition, there are 22 polytechnics catering technician courses exclusively for girls with an intake of 2,200 per year. Some of the other specialized institutions that have been set up are the institutes of management at Ahmedabad, Calcutta and Bangalore, the National Institute for Training in Industrial Engineering (NITIE) at Bombay, the National Institute of Foundry and Forge Technology, schools of town-planning and architecture and other specialized institutions in printing technology etc. In order to train teachers for polytechnics, four regional technical teachers training institutes have been established.

In terms of financial investment, the technical education system represents an investment of over Rs. 2,000 million in buildings and equipment. About twenty thousand teachers - a good proportion of them with post-graduate and research qualifications - form the faculty of these institutions. The admissions in 1974-1975 in colleges were 20,870 and polytechnics 44,000.

Post-graduate study and research

During the last decade, priority was given to the development of post-graduate education and research in engineering. There are at present 65 institutions offering facilities for post-graduate studies in a number of specialized fields Facilities have been created for an annual

intake of about 4,000. The development of the Indian institutes of technology was a significant step to promote advanced engineering education and research. The present annual output is about 200 Doctorates and 1,600 with the Master's degree in engineering. An essential component of the post-graduate programme is project work, which may be research-oriented to initiate students in the methodology of research or design-oriented to equip them with an understanding of design procedures and engineering synthesis. The utilization of Master's degree holders in the different sectors of technological activity is as follows:

Industry	43%
Research	17%
Teaching	26%
Further studies	14%

With the emphasis on self-reliance and indigenous technology, the proportion entering industry for design, development and research will rapidly increase in the coming decade.

Manpower planning

The importance of manpower planning in the field of technical education need hardly be stressed. The accelerating pace of technological change is an important phenomena of our times. Demand for technical personnel in newer areas will continuously emerge, which should be taken into account in future plans of technical education. In developing countries, insufficient attention has been paid in organizing programmes to meet the technological needs of agricultural production, agro-based industries, small industries and handicrafts. Innovations in these areas are as important as in organized medium- and large-scale industries for national development.

Continuing education

Continuing education for practising engineers has been organized at several institutions. These courses are tailored to the needs and motivations of engineers in industry. The nature of the courses has necessitated development of mimeographed notes and data sheets for utilization by the participants. The duration of these programmes generally varies from two to four weeks though some are for longer periods extending up to nine months. Though these courses are not part of any post-graduate programmes, satisfactory completion of the course enables the participant to receive an official certificate from the institution.

Operation and maintenance of plant and machinery in developing countries is of crucial importance for optimal utilization of installed capacity. These services should not be considered as mere routine and rated as second-class activity. This is just as important as research, design and production activity in an enterprise. Training programmes for engineers and technicians in this important activity are organized both by manufacturers of equipment, and in the industrial enterprise itself. The association of technical institutions in the training programmes organized by industry has been found to be mutually beneficial.

Faculty development

During the last few years, great stress has been laid on improving the quality of engineering education in our institutions. With this in view, many programmes were initiated commencing from 1969. Faculty development has rightly earned a pride of place among them. Young engineering college and polytechnic teachers have been enabled to improve their competence:

(a) by attending summer schools in specialized fields;

(b) fellowships for full-time studies and research leading to Master's and Doctor's degrees in selected technical institutions;

(c) fellowships for young teachers for a programme of residency in industries, to enable them to acquire a feel for industrial problems.

Curriculum development

Curriculum development centres have been established in all engineering disciplines at eleven institutions in the country. Faculty members from various engineering institutions and

engineers from industry have met periodically during the last four years to update the curriculum, develop new resource materials for teaching/learning, laboratory equipment development in various engineering disciplines, teaching aids, case studies of real design projects, effective teaching and evaluation methods.

In recent years, numerous educational technology systems have been developed in many countries and tested for the improvement of the teaching and learning process in engineering education. This new educational technology includes:

A. Audio-visual aids

(i) overhead transparencies for instruction in engineering drawing and kinematics with great success;

(ii) tele-media;

(iii) recording media (video-tapes, audio-tapes, films etc.);

(iv) audio-visual books (not meant as a substitute but as a supplement to good teachers).

B. Computer-assisted instructional methods (CA I)

C. Computer-aided design - In the teaching of engineering design, students derive great benefit as they are able to see the effect of a large number of parameters which would otherwise not be possible

D. Various types of mechanical, teaching and examination machines.

The development of low-cost new educational media and their standardization will enable its use by individual institutions, teachers and learners. These educational media may be combined with the usual forms of lectures, tutorials, seminars, laboratory work and project work. Studies carried out in several countries have shown the obvious advantage of the above combination for many engineering courses, particularly engineering graphics, engineering mechanics and related sciences. The new educational technology also provides for a quick feedback to the teachers in regard to analysis of their performance as well as that of students.

Innovative programmes

A few institutions are experimenting with the sandwich or co-operative programmes of education, both at the degree and at the diploma level. Industry-oriented programmes have been organized at the post-graduate level at several regional engineering colleges with assistance from Unesco. These innovative programmes are being watched with interest by other educational institutions in the country. The impact of computers in engineering education clearly points out that the undergraduate engineer of the future must be able to cope with problems in systems terms. In contrast to the current practice, challenging and exciting areas for exploitation of the computer in the solution of engineering problems are in the fields of design. "Creativity" in engineering is much sought after at the present time. Creative design can be fostered by impressing on the engineering student that every man-made device, product, system and process represent an imperfect solution to a given problem at that point of time. In many institutions, project work is assigned in the final semester of the undergraduate programme to enable the students to gain confidence in tackling live engineering problems.

The most common engineering criterion is performance/cost ratio. Economic justification is too seldom discussed in technical institutions in a meaningful way. Decision-making in the economic and technical context must be brought into the curriculum.

Young engineering teachers lack awareness of manufacturing, marketing, product development, financing and other factors that influence engineering decisions in practice. Preparation for advanced degree or teaching is so exacting that they have little opportunity for professional experience. Residencies in engineering practice should be designed to provide clinical practice for all engineering faculty members. There is a necessity for evolving a programme to prepare "professional engineers" at the graduate level, leading eventually to a Doctor of Engineering degree for innovative design and development work, in contrast to the requirements for the Ph.D. degree.

Environmental aspects in engineering education

Environmental management in developing countries needs no added emphasis at the present time. The process of environmental management raises questions regarding the specific paths of development chosen and open up the possibility of others. It touches on the final choice of goods and services as well as on the methods by which these will be produced and consumed. And it helps us to identify the most appropriate technologies, as well as other factors such as location of activities, by which waste can be minimized, recycling of materials, and the use of natural resources can be made more efficient. The presence of faculty members who possess expertise in one or more areas of environmental and behavioural sciences and who have deep motivation for work in problems concerning the interphase between man and environment or between man and machines invest the technical institutions with a capacity to launch on projects which are not purely technical in character but are rendered very complex by the presence of societal attitudes. The latter situation may arise because of the behavioural response of a group of people who are affected by the preferred solution or because of the costs involved, the economy of the situation and the like. The solution of some of the problems of the community in the neighbourhood or those relating to life in an urban or rural environment or tasks undertaken at the State or national level will invariably call for the co-operative efforts of the engineer, and the social scientist. The basic climate in which this capacity to work together on complex interacting facets of a problem should be fostered and built up in our institutions so that when projects are undertaken, say, in human settlements, water resources development, large industrial projects, resource management, transportation networks, etc., competent and understanding personnel are available to attempt its solution which is not only technological but has also environmental impact and concerns.

Industry-institution relations

Industry, as a major beneficiary of the product of universities, has always had an important stake in the education process. The young engineers from the university determine the shape of the industry and, indeed, of the society tomorrow. Various steps have been taken to bring industry and engineering institutions together - for instance, residencies in industries for faculty members to enable choice of projects for research more towards well-defined goals. The stimulus of sound academic thinking is good for the industry. The discipline of the hard school of practice is good for the faculty in the universities. The close working together of industry and academicians is essential. Some of the steps that can be taken to achieve this symbiosis is listed:

(a) co-operative undergraduate and post-graduate programmes;

(b) faculty consulting for industry both at senior and junior levels;

(c) appointment of visiting industrial professors who have strong academic learnings. They should be permitted to direct design projects and serve on curriculum committees. This is analogous to the clinical professor of medicine in medical colleges;

(d) use of visiting committees for constructive interaction;

(e) continuing education for engineers working in industry;

(f) engineers from industry and research laboratories are enabled to undergo part-time courses leading to post-graduate conferments;

(g) setting up industrial consultancy centres in technical institutions;

(h) in-house research, design and development cells in industrial establishments.

Rôle of professional societies

Professional societies in technical education have an important rôle to play in fostering continuing education programmes, new methods of teaching and evaluation, new educational technology, sharing of experience and skills and most important of all, dissemination of information regarding developments in these areas in technical institutions throughout the world. It is a matter of gratification that Unesco has played a key rôle in promoting regional associations for technical education in South and South East Asia, Europe, Middle East, Africa and Latin America.

Our engineering institutions are often immersed in details of subject-content, by numbers of subjects and of a rigidity in the requirements of subjects for all our students, that one feels that the system is designed for the least able and least motivated students. Our educational system must be designed to produce engineering managers with competence needed to integrate technology into our complex societal needs. We should have the courage to differ from conventional wisdom, in style, goal, pace and educational methods. The kind of personnel needed in developing countries like ours are those who can harness the resources to meet the society's needs. At least some of the institutions in developing countries should endeavour to train a small group of entrepreneur-engineers. An entrepreneur-engineer must be a leader, designer, synthesizer and a doer, who understands theory as a guide to practice. If, occasionally, such a kind of engineer is being created now, it is in spite of the institutional training. The future trends clearly indicate that compartmentalization, which has been the heritage in engineering institutions, will have to give way to a new structure which will bridge across these barriers.

One can foresee the broad needs of a developing country under the following six heads:

1. Food and agriculture;

2. Energy;

3. Natural resources (water, minerals, oils, forests, etc. - renewable and non-renewable);

4. Environmental management including human settlements;

5. Transport;

6. Communications.

In order to develop a programme of education for meeting the above societal needs in developing countries, centres of study and research in these areas should be established in our engineering institutions. These centres will enable our future engineers to come to grips with the whole problem of scientific, technological and human endeavour. It will promote an integrated study of the broad problems for tomorrow's engineering and most important of all, bring together the faculties in the several departments whose interests interact. It is in these centres that multi-disciplinary teams of faculty and students can experience much new learning. Societal problems are rarely unidisciplinary and team work has to be inculcated in engineering institutions so that they are in a position to tackle problems which are often open ended, not too well defined, perhaps, "mundane" but which are necessary for fulfilling the needs of a developing country. This will meet the oft repeated criticism that students coming out of our technical institutions tend to be élitist in their approach instead of using their abilities towards solving societal problems. The establishment of such centres would also enable technologists in industry, agriculture and government to return to an academic environment for intellectual refreshment and training on what might be called industrial sabbatical or study leave.

Educating tomorrow's engineers and technicians who will be useful to the society for the next three to four decades of their professional career should be in such a way that they could ride the galloping horses of change, have the will to innovate and the entrepreneurial spirit to modernize the old and to emerge as leaders in advancing the economy and welfare of the nation.

ANNEX IV

LIST OF DOCUMENTS

Main Documentation		
SC/TECHED/1	-	Agenda
SC/TECHED/2 Rev.	-	Information Note
SC/TECHED/3	-	Rules of Procedure
SC/TECHED/4	-	Annotated Agenda
SC/TECHED/5	-	Time-table
SC/TECHED/7	-	List of Participants
SC/TECHED/8	-	List of Documents
Additional Papers		
SC/TECHED/Misc. 1	-	Quantitative and Qualitative Estimation of Technological Manpower Needs
SC/TECHED/Misc. 2	-	Curriculum Design in Engineering Education - Progress Report on the Work of Unesco International Working Group
SC/TECHED/Misc. 3	-	The Environmental Education of Engineers
SC/TECHED/Misc. 4	-	Continuing Education of Engineers and Technicians
SC/TECHED/Misc. 6	-	Development of Teachers for Engineering Schools
SC/TECHED/Misc. 7	-	Revised Recommendation Concerning Technical and Vocational Education
SC/TECHED/Misc. 8	-	Rôle of Engineering Societies and the Profession in Promoting Improvement of Technological Education
SC/TECHED/Misc. 9	-	Report on Training of Engineers, Technologists and Technicians in Developing Countries
SC/TECHED/Misc. 10	-	Current Issues in Technician Education in Developing Countries
SC/TECHED/Misc. 12	-	Educating Engineers for World Development - Proceedings of the World Congress, 10-12 June 1975
SC/TECHED/Misc. 15	-	The Education and Training of Environmental Manpower in Connexion with Health

Papers distributed at the Conference

Technical Education for Development by Dr. A. Ramachandran

Strengthening the Links between Higher Education and Industry in Training Engineers in the USSR

The Rôle and Objectives of Continuing Education by Dr. Sabah A. Al-Nassri

Various Statistics and Materials on the Engineering Education and Training in Japan by Dr. Kiyoshi Korikawa

ANNEX/ANNEXE/ANEXO V

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